The Dock and Harbour Authority

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Editorial Comments

A South Carolinan Port.

Those of our readers who have perused Miss Mary Mitchell's popular novel, " Gone with the Wind " and have followed therein, the tragic fortunes—or misfortunes—of the heroine, Scarlett O'Hara, will have had a vivid picture presented to their minds of the horrors of the American Civil War during the early 'sixties of last century and of the miseries undergone by the unfortunate inhabitants of the City of Charleston in South Carolina, U.S.A., which has been selected for this month's leading port article.

Founded as far back as 1670, by a party of English colonists led by William Sayle, and named after the reigning English monarch, Charles II., the settlement was at first located some few miles distant from the present site, to which it was moved several years later, as being more favourably situated at a point where the Ashley and Cooper rivers debouch into a spacious harbour, extending about seven miles in a south-easterly direction to the Atlantic, with an average width of two miles and an entrance width of a mile.

Two centuries later, in the Civil War referred to above, between the Northern and Southern States over the slavery question, Charleston suffered severely, being bombarded and forced to surrender to the Confederate forces, which, however, later withdrew after setting fire to the public buildings, cotton warehouses, stores and shipping. These and kindred calamities, including an earthquake in 1886, are now only unpleasant memories of a distant past. At the present day, Charleston is a prosperous city and port, as our readers will be able to judge from the article in subsequent pages, which is based on the excellent monograph published by the United States War Department, to the value of whose Port Series we have frequently called attention.

In addition to being an ocean port, Charleston offers spacious accommodation to shallow draught vessels, which come from all points on the Atlantic Coast, from the Delaware River in the North to Miami in the South, via the Atlantic Intracoastal Waterway, which provides a sheltered inland route for vessels unsuited to navigate the open sea.

With this combination of sea and inland waterway traffic, Charleston is making definite headway towards a leading position among American ports.

Port and Transit Control.

The fusion of the Ministries of Shipping and of Transport has been completed during the past month by the series of appointments and official arrangements which have been notified in the daily press. Between 20 and 30 leading appointments have been made, with several transfers and the introduction of new men to new posts. From the point of view of our readers, the centre of interest lies in the department of Port and Transit Control; this, indeed, is the pivot on which the successful operation of the entire combination hinges. Port work, in so far as it is outside the sphere of the local port authority, has hitherto been partly in the domain of the Minister of Transport and partly in that of the Minister of Shipping and their respective areas of activity have been somewhat nebulously defined, with the result that there has been a certain amount of overlapping and a lack of proper co-ordination, which, in turn, has led to delays, waste of time and energy and not infrequently to congestion and confusion.

The Port and Transit Control, under the direction of Mr. Basil Sanderson, will henceforth supervise the primary contacts of shipping with rail, road and inland water transport. By this means it is intended that the movements of shipping and of inland transport shall be linked with port operation through one central agency. There is also a Director of Ports (Mr. R. H. Tolerton) who, presumably, will ensure that local effect is given to the decisions of the Control, though the precise duties of the post under the scheme are not altogether clear, nor the relationship between it and certain Regional Port Directorates, which apparently become subordinate to the Central Directorate. The actual process of the turn-round of ships comes under the Shipping (Operation) Control, of which Sir F. Vernon Thomson is chairman.

The new Ministry of War Transport is obviously a very large and complex organisation, embracing as it does the whole field of transport for overseas trade, and we must confess that we get the impression that it may prove unwieldy and cumbersome. It is to be hoped that the various sections will work with one another harmoniously and efficiently, and that there will be no unnecessary circumlocution and superfluous " paper work." To facilitate intercourse, all the divisions of the Ministry are to be housed in the same building; this should undoubtedly facilitate ready conference and prompt action. On the other hand there is the danger of too much conference and too little action.

Dockside Labour Troubles.

It is regrettable to have to record that the past month has been marked by disagreeable episodes at the ports of Manchester and Liverpool, arising out of labour disputes and resulting in the temporary suspension from work of several hundreds of dockers, following a lock-out at Manchester on June 12th. The ostensible cause of the dispute was connected with overtime work, but the men also put forward a grievance on account of the alleged inadequacy of canteen facilities. This latter matter has since, we understand, been rectified. The root cause of the trouble, however, is stated by Union officials to be the subversive action of Communists, who have endeavoured to spread disaffection among the workers. The agitators in question, described as being of " a bad type," have now been got rid of, and at the moment of writing, work at the ports is said to be progressing smoothly.

At the same time, it is to be gathered from articles appearing in the daily and weekly press that conditions are not altogether satisfactory at a number of ports. There is evidence of idleness and deliberate dodging of work, in particular at Liverpool and Glasgow, aggravated at the latter place by pilferage and organised theft. The Special Industrial Correspondent of a London Daily, while reprobating the action of the dockers, insists that employers must take some share of the blame. " Idle and inefficient minorities on both sides," he says, " are creating a spirit in the docks which will not help to win the war and while this state of affairs continues, the country will be paying thousands of pounds a week for no return."

Point is given to the accusation by passages in the Sixteenth Report of the Select Committee on National Expenditure, just issued, extracts from which are to be found on a subsequent page. The Committee ascertained that at one port, because of a temporary reduction in the demand for labour, the system of a guaranteed minimum wage involved the Ministry of Transport at the end of the first week in the payment of a considerable sum, for which no service was rendered, and their Report goes on to admit that it may be argued that the new schemes are more expensive in operation than the old casual system, only suggesting that, under certain conditions, the higher cost may be offset by the greater mobility and efficiency of dock labour. This is rather cold comfort for the unfortunate taxpayer.

The main trouble, however, is that there is a certain proportion of dock labour (we have no idea of its extent, though we trust it is small) is recalcitrant and purely self-seeking. It does not hesitate to

Editorial Comments– *continued*

exploit the national emergency for its own ends: chiefly, more pay for less work. The Committee Report affirms that some of the men are deliberately attempting to evade work, so long as they do not thereby imperil their right to receive the minimum weekly wage. The policy hitherto adopted by the Ministry of Labour, that of apologetic appeasement, is to be deplored. There should be the application of as rigid a standard of discipline in port labour as is enforced in other services of the nation in the present stern struggle for national existence and liberty. It is no time to mince matters. Something more than smooth words and coaxing is needed to deal with men who are lacking in patriotic feeling and duty.

American Port Propaganda.

Under the somewhat curious title of Port Preparedness Dedication, the Port of New York recently staged a celebration which, in essence, seems to have been designed mainly for propaganda purposes. Not that we raise the least objection to port propaganda: it is really an excellent and a necessary thing. Only it seems a little odd that it should have been wrapped up, so to speak, in an altruistic parcel. To quote from a report in the American press, " Mr. Frank Ferguson, chairman of the Port of New York Authority" (in a speech inaugurating the movement) "emphasised the fact that New York is a confederation of many municipalities and of port facilities, constantly growing more interdependent and indicated that the Port Preparedness Dedication will dramatize the achievements of the individual sections of the district, as well as the port as a whole. He foreshadowed publication by the Port Authority of a special report, which will give a port-wide picture of the development, functioning and advantages of the entire Metropolitan District." In other words, the Port Authority intended to boost the city, while, at the same time, putting in a word for itself.

The observance of the celebration occupied three days at the end of April and invitations to participate were sent out, jointly by the Port Authority, the Mayor's Business Advisory Committee and the New York State Chamber of Commerce, to " 150 civic leaders and representatives of the shipping, industrial, banking, transportation and publishing fields." Mr. Ferguson took the the opportunity at a public meeting to point out that " despite emergency conditions, despite a load which is already as great as the last World War, commerce is moving smoothly and expeditiously in and through the port of New York. The chaotic conditions, the bottlenecks which existed at the port during the last war, no longer exist. These facts," he said, " should be brought home to shippers all over the country."

The " Dedication " was marked by various ceremonies, concluding the presentation of medals to " forgotten men," including the oldest pilot, shipyard worker, longshoreman (dock labourer), tow-boat captain, deep sea diver, barge captain, railroad yardman, lighthouse keeper, dredge operator and harbour fireman or policeman. These awards, based on length of service, were made on the result of a poll carried out by maritime and trade associations in New York and New Jersey.

Certainly a unique conception on the part of the Port of New York Authority, to whom we offer respectful congratulations on an effective combination of business and sentiment. It is to be hoped that it has met with appropriate success.

Port Aesthetics.

The Council of the Institution of Civil Engineers have initiated a movement which may come to have an important influence in the future on the design of quayside buildings. Hitherto in port works, architectural aesthetics have been largely ignored, or treated as if of minor importance. Utility, and utility alone, has been the rigorously observed ideal. Anything in the way of graceful or pleasing ornamentation has been considered out of place. Hence it is that, in the past, British landing places and maritime stations have too often, with their drab and sordid environments, been the means of imparting a feeling of cheerless gloom and inhospitable reception to incoming visitors from abroad. The general aspect of the majority of dockside transit sheds and warehouses, with their adjacent grimy purlieus, cannot by any stretch of imagination be called inspiring, and there are many other instances which might be given of a disregard for quite reasonable amenities in port areas. Happily this state of affairs is now invoking criticism, resulting in amendment. Of late, there have been outstanding instances of an improved degree of treatment.

The Council of the Institution announce that they have approached the Vice-Chancellor of Cambridge University with an offer, which has been accepted, to finance, for a period of five years, a lectureship on the relations of aesthetic considerations to engineering design and construction, linked with the economics of engineering projects and the organisation and management of engineering work. As we have on several occasions called attention to the manifest care, and even elegance, with which modern Maritime Passenger Stations abroad are designed and executed, in striking contrast to certain stations still in use in this country, we naturally welcome this courageous attempt to create a higher architectural standard for engineering structures, which, we hope, will be extended to British port installations generally.

Coastal Shipping and Port Costs.

At the Annual Meeting of the British Motor and Sailing Ship Owners' Association, recently held in London, the Chairman, Mr. W. J. Everard in the course of his address referred to a matter of importance affecting not only shipowners, but, ultimately, the general body of the public. He deplored the rising scale of port charges for pilotage, dock services and light dues—matters which particularly concerned the coasting trade on account of the frequency with which vessels engaged therein moved in and out of port. Admitting that, for the moment, deep sea traders were not so much affected, since such costs fell in the main on the Ministry which had requisitioned their ships, yet, he contended, the position for all sections of the industry would be extremely serious at the end of the war, when owners traded their own ships again and returned to competitive rates of freight. They would find themselves faced with port costs which had rocketed up and which it would take a very long time and much labour to reduce, as was the case after the last war.

The remedy, or corrective, suggested by Mr. Everard, was the making of Government grants to the various port authorities to help them to tide over the difficult war-time period. This action would involve, of course, the taking of steps to see that the services were run on lines of strictest economy and efficiency. The proposal is controversial and will probably not command universal approval. Despite, however, the objections to be urged against the artificiality of subventions and subsidies in general, we think there is much to be said in favour of a temporary system of port subsidies in order to avoid the worse evil of inflated charges, which as Mr. Everard points out, must inevitably be passed on to the freights themselves and result in higher prices for the commodities involved. These, in turn, will enhance the cost of living and give rise to demands for higher rates of pay. It is another instance of the " vicious spiral," which, in the long run, will be of no benefit to anybody.

The St. Lawrence Deep Waterway.

The signing of an agreement in March last between the Governments of the United States and Canada for the joint creation of a ship channel in the River St. Lawrence between Montreal and Lake Ontario followed last month by a Presidential recommendation to the United States Congress for immediate execution as a National Defence measure, makes the following brief particulars of the scheme appropriate and interesting. Including the hydro-electric generating installation, the total cost of the project is £66,542,000.

The new channel is to have a ruling depth of 27-ft., so as to provide navigable passage for shipping of 25-ft. draught. The present canal system along the St. Lawrence above Montreal is only 14-ft. deep. Below Montreal there is adequate depth for vessels drawing well over 25-ft. In order to provide the 25-ft. standard of draught above Montreal, it will be necessary in the first place to deepen the Lachine Canal from 14-ft. to 27-ft. at an estimated outlay of $55,000,000.

The next obstacle to be overcome is at Beauharnois, where a canal connecting Beauharnois and Valleyfield is in existence for power generating purposes. It is of sufficient amplitude to accommodate seagoing ships, but in order to render it accessible from the lower reaches of the river it will be necessary to construct at Beauharnois a set of locks by means of which ships, after passing out of the deepened Lachine Canal and traversing Lake St. Louis, will be raised 80-ft. to the level of the Power Canal. From Beauharnois, ships will proceed through this canal to Valleyfield, and thence through Lake St. Francis and part of the St. Lawrence River to Barnhart Island, near the town of Cornwall in Ontario, where a new large dam is to be built. Here, by means of a further set of locks, ships will be raised another 80-ft. or more to enable them to reach Lake Ontario without further locking, unless an additional lock be found necessary at the dam near Iroquois.

At Barnhart Island, the locks will be located on the United States side of the dam, but the existing 14-ft. locks on the Canadian side will be preserved for subsidiary uses. The new dam will eliminate two notable rapids at Galop and Long Sault, which will become submerged in a single artificial lake.

Up to the last there has been a considerable amount of opposition to the project, arising from interests which consider that they will be adversely affected by its execution, chiefly in and around the Port of Montreal which will cease to be an ocean-terminal port, and in the Mississippi Valley, where an alternative traffic route eliminating rail competition is not welcomed. However, as the initial step for the materialisation of the new waterway has now been officially and irrevocably taken, the opposition will perforce gradually die down and disappear.

*The Port of Charleston, South Carolina, U.S.A.**

General View of Charleston Harbour and West Bank of the Cooper River, Looking North, Battery Park in Foreground.

General Description

CHARLESTON HARBOUR, on the Coast of South Carolina, about 174 statute miles South-west of Wilmington, N.C., 114 miles North-east of Savannah, Ga., and 228 miles North-east of Jacksonville, Fla., is one of the most important seaports on the South Atlantic Coast of the United States of America. It is formed by a bay at the mouths of Cooper and Ashley Rivers and is nearly landlocked by outlying seacoast islands and portions of the mainland. The City of Charleston is located at the confluence of the Cooper and Ashley Rivers, at the head of the bay, and is 7½ miles from the ocean bar. The entrance from the sea is through a channel protected by two stone jetties. The north jetty is 15,443-ft. long, the south jetty 19,104-ft., and the distance between their axes at the outer end is 2,900-ft. From the inner end of this channel in deep water of the lower bay the main channel extends in a Westerly direction to the Southern end of the peninsula formed by the junction of the Cooper and Ashley Rivers, thence for a distance of 8 miles in a Northerly direction up the Cooper River, passing to the East of the wharves of Charleston and to the East of Drum Island, to the United States navy yard. There is also a navigable channel through Town Creek on the West side of Drum Island. The channel has been dredged also from the navy yard to the port terminal (formerly the Army supply base) a distance of 2½ miles and thence to the ordnance depot, one-half mile further. The controlling depth from the sea to the ordnance depot through both Cooper River and Town Creek in June, 1939, was 30-ft. at mean low water. Vessels of 15-ft. draft may go up the Cooper River channel a distance of 22 miles above the navy yard, while vessels of 5-ft. draft may go as far as Wadboo Bridge, a distance of 49 miles above the navy yard.

From the Southern end of the peninsula there is also a dredged channel 30-ft. deep extending for 7¼ miles in a North-westerly direction up the Ashley River to the site of the former Standard fertilizer wharf.

The bar channel outside the jetties is exposed to heavy seas, while the channels in the bay and in the two rivers are well protected.

Wando River, which empties into Cooper River eastward of Drum Island, affords a natural channel 14-ft. deep to the river's intersection with Guerin Creek, a distance of 13 miles from the mouth; thence a channel with a controlling depth of 3-ft. to Woodville, 16 miles above the mouth, and thence to Wards Bridge, 20 miles above the mouth.

Shipyard River is a small tidal tributary of Charleston Harbour, having its source about one-half mile below the United States navy yard, from whence it flows in a South-easterly direction for approximately 3 miles, emptying into Cooper River about three-eighths of a mile from Drum Island. There is a dredged channel in this river having a controlling depth of 30-ft. to the head of the Gulf Oil Corporation Wharf, where a turning basin is provided; thence from the Gulf Oil Corporation Wharf to a point 50-ft. above the Tuxbury Lumber Co Wharf, a distance of seven-tenths of a mile, the channel has a controlling depth of 12-ft., and project depth of 20-ft. recently restored.

The Atlantic Inter-coastal Waterway provides an artery for water transportation connecting the Port of Charleston with other coastal ports to the North as far as Norfolk, Va., and thence through Chesapeake Bay and the Delaware and Chesapeake Canal to Philadelphia, Pa., and other Delaware River ports. To the South the waterway extends to Miami, Fla.

The available depths at mean low water in the waterway are from 8 to 9-ft. between Charleston and Winyah Bay to the North and 7-ft. between Charleston and Beaufort, S.C., to the South. This latter stretch is now being deepened to 12-ft., which is the project depth for most of the section of the waterway.

The waterway enters Charleston Harbour from the North at Sullivan's Island, and from the South it enters Ashley River through Wappoo Creek.

Tides and Tidal Currents

The mean range of tides at Charleston is 5.2-ft., which is increased to 7 or 8-ft. by North-east winds or storms of long duration. The mean tidal variation in the Ashley River is 5.2-ft.

The tidal currents off the entrance are revolving and those between the jetties and in the harbour generally set fair with the channel near its axis. Outside Fort Sumter, branches from the main ebb current set through the openings between the jetties and the shore with a velocity of about 2 knots at strength. The velocity of the flood current is less than the ebb, depending on the freshet flow from the rivers. Slack water occurs between the jetties at about the time of high and low water at Charleston.

Anchorages

The usual anchorage is known as "Lower Anchorage." It lies immediately inside the bay North of the South Channel and South-eastward from Charleston. It affords good holding ground but is somewhat exposed to South-east gales. The depth ranges from 27 to 50-ft. at mean low water. The best anchorage is in the mouth of the Wando River, Eastward of Drum Island, about 1 mile North of the city. This anchorage affords good holding ground and is protected from storms. The quarantine anchorage is on the South side of South Channel, 2 miles South-east of Charleston, abreast of Fort Johnson; it is marked by two yellow buoys.

Vessels are forbidden to anchor North-eastward of Fort Sumter and between Fort Sumter and Sullivans Island on account of the

*Abridged extracts from Port Series No. 9 prepared by the Board of Engineers for Rivers and Harbours, U.S.A., War Department, and the Division of Research, United States Maritime Commission.

Port of Charleston—continued

submarine cables crossing at that point. Vessels are also forbidden to anchor in the stream opposite the Eastern part of the city, except North-eastward of Union Pier and South-eastward of the Southernmost wharves, and they must then anchor so as to give the wharves a clearance of not less than 200 yards when swinging toward them.

Climatic Conditions

Winds.—The prevailing winds are South-west from January to August, North-east in September and October, and North in November and December.

Fogs.—Fogs seldom occur except in January, February, and December. In the fall and winter the Gulf Stream is frequently marked by a thick haze of vapour.

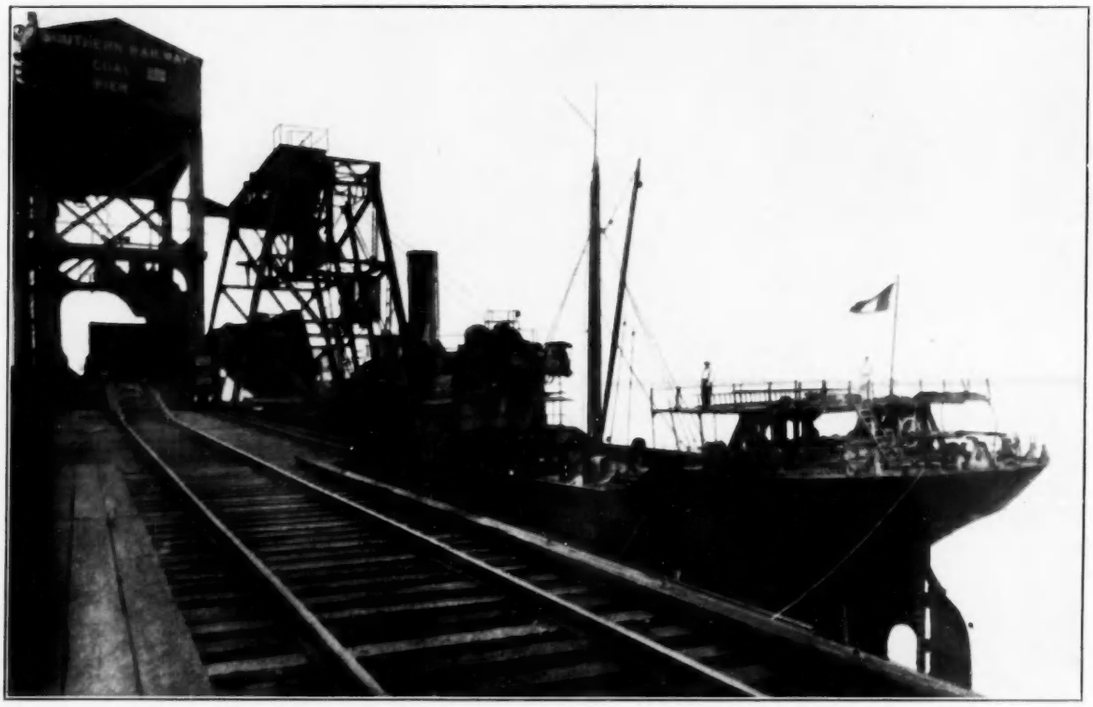
Precipitation.—The mean annual precipitation for 68 years is 46.68 inches. The greatest precipitation occurs during June, July, August and September.

From the inner end of the jetties to the navy yard via the Cooper River there is a 30-ft. channel 600-ft. wide, except opposite the naval reservation, where the controlling depth is 25.4-ft. for project width and 30-ft. for a width of 400-ft. Project dimensions obtain from the navy yard to the port terminals, except at the South end of port terminals, where the controlling depth is 19.6-ft. for project width and 30-ft. for a width of 600-ft. In Town Creek the controlling depth is 22.0-ft. for project width and 30-ft. for a width of 450-ft.

Ashley River.—The existing project for the improvement of the Ashley River provides for a channel 30-ft. deep at mean low water and 300-ft. wide, extending from the mouth of the river to the site of the former Standard Wharf, a distance of about 7¼ miles, with widening at bends, and a turning basin at the head of the improvement. Dredging operations have been conducted in the river, and project dimensions are available.

Shipyard River.—The existing project for the improvement of Shipyard River provides for a channel 30-ft. deep at mean low water and 200-ft. wide, widened to 670-ft. at the entrance from deep water in Cooper River to a point 100-ft. above the Gulf Oil Corporation Terminal, with a turning basin 30-ft. deep at the latter point, and for an extension of this channel 20-ft. deep and 100-ft. wide, widened at bends, to a point 50-ft. above the Tuxbury Lumber Co. Wharf.

The existing project was completed in 1939. However, shoaling in the 20-ft. channel above the Gulf Oil Corporation terminal limits the depth in that portion to 12-ft. From the mouth of the river to the Gulf Oil Corporation Wharf, project dimensions obtained in September, 1939.



Ship Loading at Southern Railway Coal Pier, Charleston, S.C.

Bridges

Ashley River.—There are two bridges with openings 110 and 100-ft. wide across the improved portion of Ashley River; the first is at Charleston about 2 miles above the mouth; the second is the Seaboard Air Line Bridge, 3 miles above the mouth. The Atlantic Coast Line Railroad has a bridge at Bees Ferry, 12 miles above the mouth of the river. This bridge requires caution when passing up the river on the ebb current, which sets across the end of the draw.

Cooper River.—One bridge crosses Charleston Harbour opposite Lee Street. This bridge has a fixed span over the Town Creek Channel, with a vertical clearance of 135-ft. at mean high water for a clear width of 600-ft.; and also a fixed span over the Cooper River Channel, with a vertical clearance of 150-ft. above mean high water for a clear width of 300-ft., and a vertical clearance of 135-ft. for a clear width of 1,000-ft.

Harbour Improvements by the United States

The original project for the improvement of Charleston Harbour was adopted by the River and Harbour Act of August 30th, 1852. The existing project, authorised by the River and Harbour Acts of June 18th, 1878, August 8th, 1917, July 18th, 1918, and January 21st, 1927, provides for commercial purposes a channel 30-ft. deep, 1,000-ft. wide, from the sea to the inner end of the jetties; thence 600-ft. wide to the navy yard, and thence 400-ft. wide to Goose Creek, with a turning basin 700-ft. wide at the port terminals, together with a channel 30-ft. deep at mean low water and 500-ft. wide through Town Creek. The jetties protecting the entrance channel across the bar were completed in 1895. In 1939 the project was complete except for the extension of the channel from the ordnance depot wharf to the head of the project at Goose Creek. Project dimensions obtain between and beyond the jetties, except at 2 shoals, 1 on the outer bar and the other at the inner end of the jetty channel, where project depth is available for a width of 850-ft. and project width is available for depths of 29.4-ft. and 25.2-ft. respectively.

Public Terminal Improvements

The Port Utilities Commission, under its plan of owning and operating public terminals and warehouses, has already reconstructed the Union Pier. In conjunction with this facility it is operating the Union Public Warehouse with a storage capacity of 136,000 sq. ft.

The Columbus Street Terminal, now under operation by the Commission, is used mainly for the receipt, shipment, and storage of general cargo. The berthing capacity is 1,307-ft. and there are 72,000 sq. ft. of transit shed space available in addition to 40,500 sq. ft. of storage space.

The Shipyard River Terminal Co. operates a terminal at which fertilizer and materials are the chief commodities handled. The berthing capacity is 430-ft. The terminal has warehouse storage space of 138,000 sq. ft.

The municipal yacht basin on Ashley River, near the foot of Calhoun Street, is a public facility provided by the City of Charleston for mooring recreational craft. The berthing space available is 2,742 linear feet.

Ownership of Water Front

Cooper River.—There is practically a continuous series of piers and wharves extending for a distance of approximately 2 miles on the eastern water front of the City of Charleston. About one

PORT OF
CHARLESTON
Scale.
COOPER RIVER
ASHLEY RIVER
CLOUTER CREEK
TOWN CREEK
DRUM ISLAND
DUCK ISLAND
City Boundary
WAPPOO CREEK
NAVY YARD
S.A.L. RY.
INTRACOASTAL WATERWAY
Scale of Miles

Port of Charleston—continued

half of these wharves are owned by railroad and steamship companies and by the port utilities commission of the City of Charleston, while the other half are owned by private interests.

Ashley River.—There are seven terminal facilities located on the Ashley River between Tradd Street and the wharf of the Virginia Carolina Chemical Co., a distance of 5½ miles. One of the wharves is owned and operated by the United States Government, one terminal is operated as a municipal yacht basin, and the remainder are privately owned.

Shipyard River.—The three terminals on the river are privately owned. They are the Shipyard River Terminal, the Gulf Oil Corporation Wharf and the North State Lumber Co. Wharf.

Coal Bunkering

The requirements for bunker coal at Charleston are amply supplied at the Southern Railway coal pier and at the facilities of the Southern Ice Co. and William Johnson and Co. Coal can be delivered to vessels at the Southern Railway Coal Pier at the rate of 26 cars per hour through a coal-dumping machine equipped with a trimming device on the chute. Trimming is further facilitated by the mobility of the dumper which is mounted on rails and can be moved along the wharf, making it unnecessary to shift the vessel. The berthing space at this facility is 455 linear feet with 28-ft. of water alongside at mean low water.

The wharf of William Johnson and Co. is equipped with two belt conveyors, each with a delivery capacity of 15 to 18 tons of coal per hour. There are 250 linear feet of berthing space at the wharf with 24-ft. of water at mean low water.

The coal plant of the Southern Ice Co. delivers coal to vessels at the rate of from 10 to 12 tons per hour by the use of a portable belt conveyor. The berthing space is 70-ft. with 10-ft. of water alongside.

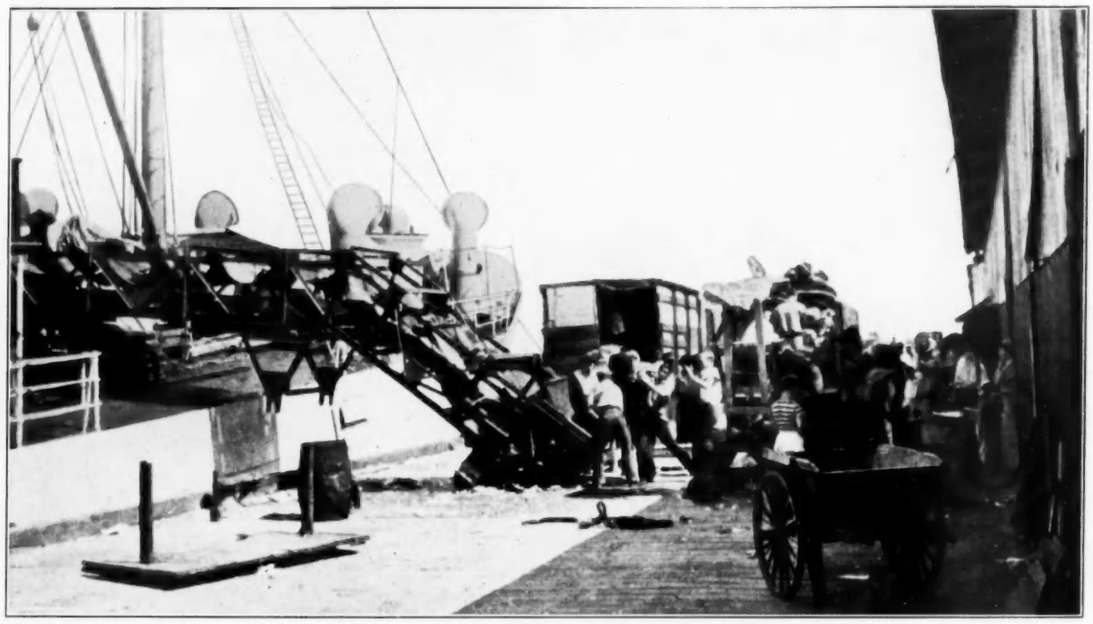
Piers, Wharves and Docks

There are 39 piers. wharves and docks in the port, 29 of which are situated on the Cooper River, 3 on Shipyard River and 7 on Ashley River. These facilities provide a total berthing space of 21,819 linear feet, not including the berthing space at the two yacht basins. The majority of the wharves are of open pile and timber deck construction, and have from 20 to 30-ft. of water alongside at mean low water. A depth of 30-ft. or over is available at 15 terminals in the port.

The City of Charleston owns 5 terminals, which are administered by the Port Utilities Commission. One of these (Reference No. 1) is the former United States Army Supply Base and has been leased to the West Virginia Pulp and Paper Co. for private purposes. The Columbus Street Terminal (Reference No. 12), a public terminal for general cargo, has 36-ft. of water alongside at mean low water and is provided with 72,000 sq. ft. of transit-shed space. It is served by the City Belt Line with two surface tracks on the apron and four depressed tracks in the rear of the transit sheds. Union Pier (Reference No. 23) with 30-ft. of water alongside, is occupied by the American-Hawaiian Steamship Line and the Bull Steamship Co. Adger's North and South Wharves (Reference Nos. 31 and 32) are leased to the White Stack Towboat Co., which operates them for its own purposes and also as public wharfage for inland waterway vessels discharging vegetables, etc., and for vessels serving ship chandlers.

Five terminals are owned by railroads. The Atlantic Coast Line Railroad operates a pier (Reference No. 13) a short distance below the Columbus Street Terminal on Cooper River, for the receipt of general cargo and vegetables. It has 18-ft. of water alongside. The Seaboard Railway owns a pier near the foot of Hasell Street (Reference No. 21) with 30-ft. of water, which is leased to Frederick Richards for the receipt and storage of fertilizer materials. The Southern Railway operates three terminals. One, a coal-handling pier (Reference No. 11), has 28-ft. of water and is located opposite the upper end of Drum Island on Cooper River. Southern Railway Pier No. 1 (Reference No. 20), at the foot of Wentworth Street, extended, has 30-ft. of water and is operated by the railway for the receipt of vegetables for shipment beyond by rail, while Southern Railway Pier No. 2 (Reference No. 19), which also has 30-ft. of water, is leased to the United Fruit Co.

There are four piers occupied by regular steamship lines which operate on schedule. Those in use by the American-Hawaiian Line, the Bull Steamship Co., and the United Fruit Co. have been described. In addition, the Clyde-Mallory Lines operate two piers with from 26 to 30-ft. of water alongside, located at the foot of Queen Street (Reference Nos. 28 and 29).



Unloading Bananas at Columbus Street Terminal.

The appliances installed for fire protection at the terminals, in addition to the services performed by the city fire department, consist of hydrants, hose, chemical extinguishers, and fire pumps. There are also sprinkler systems in the sheds. Some tow boats in the harbour are equipped with pumps and nozzles and are available to assist in fire fighting along the water front.

Hoisting Facilities

Facilities for handling heavy lifts at Charleston are limited. There are two steam locomotive cranes on the wharf of the West Virginia Pulp and Paper Co. (Reference No. 1). One of these has a capacity of 20 tons with a 15-ft. reach, while the other is a 2-ton crane with a 40-ft. reach.

Two 12-ton steam locomotive cranes, each with a reach of 20-ft., are operated on the piers of the Charleston Shipbuilding and Drydock Co. (Reference Nos. 15 and 16), and a 5-ton hand-operated fixed derrick with a 45-ft. reach is available on the wharf of the Oakdene Compress and Warehouse Co. (Reference No. 4).

Storage Warehouses

The storage facilities in the port are all situated either on the piers or in the immediate vicinity of the water front. There are seven facilities for the storage of cotton and general merchandise, and one for fertilizer materials, representing a total of 1,153,160 sq. ft. of floor space. Practically all of the warehouses have railroad connections.

Bulk Freight Storage

An area of approximately 14 acres situated on city property in the rear of Columbus Street terminal is available for bulk freight open storage. This area has good highway approaches and part of it is served by City Belt Line trackage.

Drydocks and Marine Railways

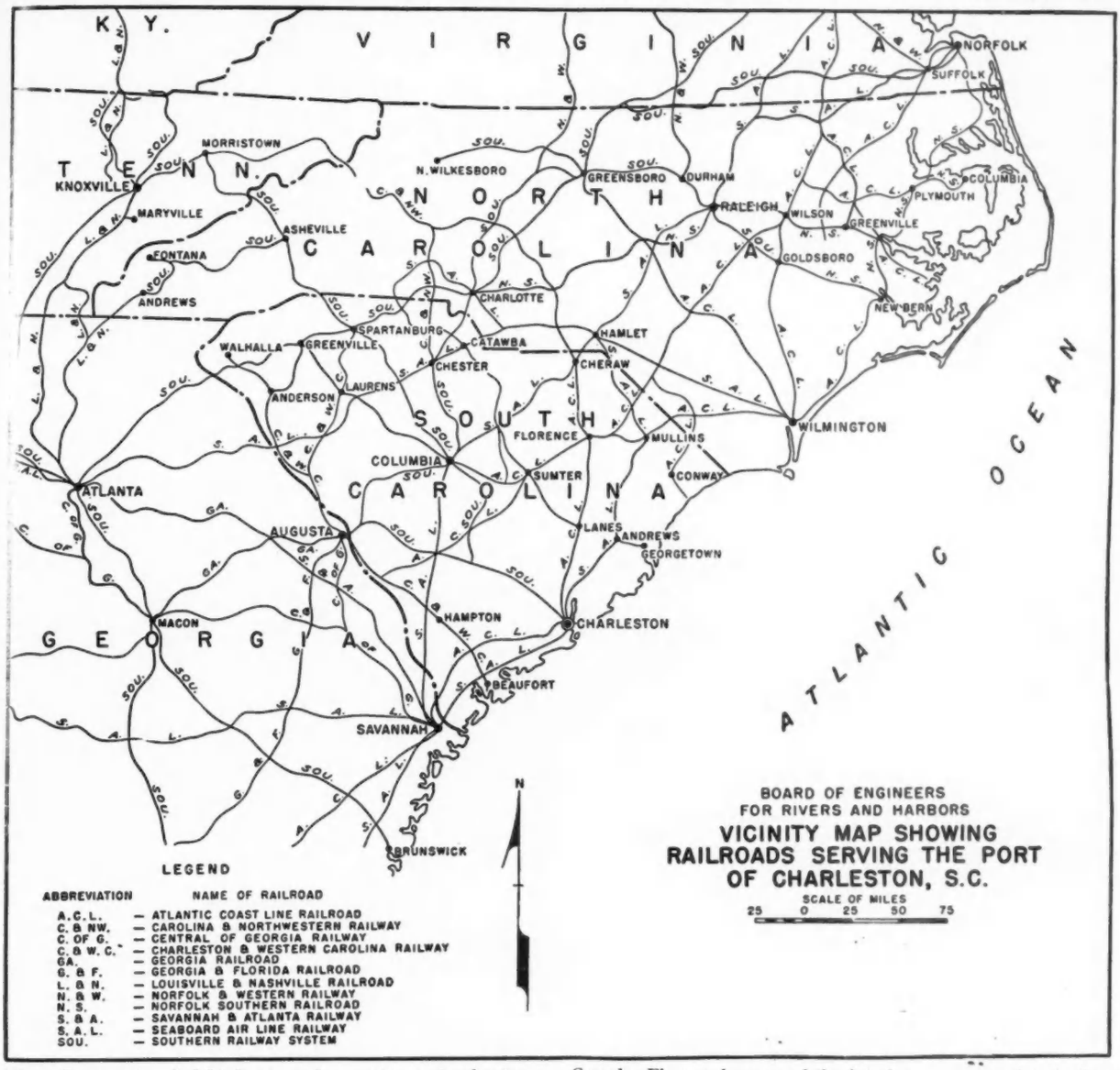
Although there are no public dry docks at the Port of Charleston, there are three marine railways with capacities of 1,500, 500 and 25 tons. There are also two 250-ton marine railways at Mount Pleasant, on the east side of Cooper River.

Port of Charleston—continued

Floating Equipment

The towing facilities at the Port of Charleston comprise 15 vessels, ranging in horse-power from 36 to 1,100. Three of the tow boats equipped with 36 horse-power engines, are used by the owners for private purposes. The other 12 are operated for general harbour and ocean towing; two have 60 horse-power engines, six range from 150 to 375 horse-power, three from 500 to 650, and one is 1,100 horse-power.

There are five lighters and barges having cargo capacities ranging from 85 to 450 tons, which are used for transportation of freight. Two motor freight boats and a motor water boat are operated by ship chandlers.



Railroad Services

The Port of Charleston, S.C., is served by three important railway systems, as follows: Southern Railway System, Atlantic Coast Line Railroad, and the Seaboard Air Line Railway.

The Southern Railway System operates about 8,000 miles of track in Southern and South-eastern territories, reaching most of the important points in the States South of the Ohio and East of the Mississippi Rivers. Its lines extend to all South Atlantic ports except Wilmington, N.C., and Fernandina, Fla.; also to Mobile and New Orleans, on the Gulf of Mexico. The system lines extend also to Memphis, Tenn.; and St. Louis, Mo.; on the Mississippi River, and to Cincinnati, Louisville and Evansville on the Ohio River. This system, in connecton with the Southern Pacific Lines at New Orleans, forms one of the important transcontinental routes.

The Atlantic Coast Line Railroad, as its name suggests, follows generally the Atlantic Coast Southward from Richmond and Norfolk, Va.; to Jacksonville, Tampa, and Everglades, Fla. Its lines reach all South Atlantic ports except Fernandina, Fla.; and many of the common points in South-eastern territory, including Fayetteville, N.C.; Columbia, S.C.; Augusta, Albany, and Valdosta, Ga.; and Montgomery, Ala. At Richmond, Va., direct connection is made with the Richmond, Fredericksburg and Potomac Railroad for points North and West, and at Montgomery, Ala., with the Louisville and Nashville Railroad for points in the South and South-west. At Norfolk, Va., connection is made with all diverging railroads and steamship lines. A total of about 5,000 miles of track is operated.

The Seaboard Air Line Railway operates about 4,000 miles of track in the same general territory as the Atlantic Coast Line Railroad, above described. Its rails reach the Ports of Norfolk, Va., Charleston, S.C.; Wilmington, N.C.; Savannah and Brunswick, Ga.; Fernandina, Jacksonville, Miami, Tampa, and Boca Grande, Fla.; and many of the interior common points in South-eastern territory. At Richmond, Va.; Atlanta, Ga.; and Birmingham, Ala; connection is made with all diverging rail lines and at Norfolk with all railroads and steamship lines.

Facilities for Interchange Between Rail and Water

Approximately half of the piers, wharves, and docks in the port have railroad connections. Six terminals have railroad trackage on the wharf or pier aprons thus permitting direct transfer of freight between rail and vessel. They have from 30 to 36-ft. of water alongside at mean low water. These terminals are the Army Base Terminal (Reference No. 1), Columbus Street Terminal (Reference No. 12), Southern Railway Pier No. 1 (Reference No. 20), Union Pier (Reference No. 23), Clyde Steamship Co. Pier No. 1 (Reference No. 28), and the Wood Preserving Corporation Wharf (Reference No. 37).

Through the use of hand trucks or conveyors interchange between rail and water is made at 13 other terminals, since the tracks at these terminals are situated in the rear of the transit sheds or are not parallel to the wharf aprons.

Commerce

The average annual volume of water-borne commerce at Charleston during the 10-year period 1929-38 was 2,177,473 tons, of which 29.2 per cent. was in foreign traffic, 57.1 per cent. in coastwise traffic, 11.2 per cent. in internal traffic and 2.5 per cent. in local traffic.

Port of Charleston—continued

Commencing the decade with 2,680,934 tons, the volume of commerce declined annually to the low point of 1,646,564 tons in 1932, from which it recovered gradually to 2,009,949 tons in 1935. It remained practically at the same level in 1936 and then rose sharply to 2,902,782 tons in 1937, the high point during the 10-year period. In 1938, it dropped to 2,387,820 tons.

Imports

The volume of imports declined from 557,655 tons in 1929 to 272,235 tons in 1933, followed an upward trend to 587,181 tons in 1937, and then dropped to 474,480 tons in 1938. The average annual volume of foreign cargo tonnage received during the 10-year period was 427,811 tons. Petroleum products, mainly crude oil, comprised 41.8 per cent. of the receipts from abroad, while fertilizer material, of which the principal items were nitrate of soda, manure salts, ammonium sulphate, and potassium chloride, accounted for 34.4 per cent.

Charleston Shipbuilding and Dry Dock Co. in Foreground and other Facilities on West Bank of Cooper River.

Exports

The annual volume of exports handled at Charleston during the decade was fairly stable, the average annual fluctuation being 14.3 per cent. The peak volume, amounting to 281,377 tons, was handled in 1937, while the smallest annual volume was 151,627 tons in 1931. The average annual volume of exports was 207,718 tons, the principal commodities being coal, which comprised 33.2 per cent.; lumber which accounted for 17.6 per cent.; and cotton, 16.7 per cent. Exports of coal increased considerably during the last 4 years of the decade, reaching the peak volume, 104,382 tons, in 1938. The average volume of coal exported throughout the 10-year period was 68,957 tons.

Coastwise Receipts

The principal traffic of the port, in point of volume, is in coastwise trade, and the movement in this class of traffic is predominantly inbound, representing an annual average of 45.9 per cent. of the total water-borne traffic of the port. There was a wide fluctuation in the in-bound coastwise movement during the 10-year period. Commencing the decade with 1,213,007 tons, the volume declined to the low point of 794,753 tons in 1932, recovered during the succeeding 4 years to 966,797 tons in 1936, increased sharply to 1,360,683 tons in 1937, and then dropped to 1,048,785 tons in 1938. The phenomenal rise in the volume of coastwise receipts in 1937 is not traceable to any one commodity, but was contributed to largely by increased receipts of petroleum products, fertilizer material, iron and steel manufactures, lumber, sulphur, salt, rubber manufactures, and several other unrelated items indicating a general upturn in business activity in that year. The average annual volume of coastwise receipts during the 10-year period was 1,000,180 tons, the leading commodity being petroleum products, which comprised 77.7 per cent.

Coastwise Shipments

The annual volume of coastwise shipments from Charleston fluctuated between the limits of 133,920 and 296,417 tons during the 10-year period with the exception of the year 1930 when it rose to 460,901 tons. The outstanding volume moved in that year was due to increased shipments of petroleum products, lumber, cross ties and flour.

Port Administration

Jurisdiction over the Port of Charleston, other than that exercised by the Federal Government, is vested in two organisations, the Board of Harbour Commissioners of the Port of Charleston and the Port Utilities Commission of Charleston. The former is primarily interested in exercising supervision over the waters of Charleston Harbour and bay and all rivers and creeks flowing into them, while the latter operates the wharves, warehouses, and terminal facilities owned by the City of Charleston, and has supervisory jurisdiction over those owned or operated by all transmitting and transporting corporations, firms, or individuals engaged in business as public warehousemen or wharfingers. Both of these commissions were organised under authority granted by the State Legislature to the Governor and to the City of Charleston. The former is responsible to the Governor and the general assembly while the latter as an agency of the city is responsible to the mayor and city council.

Board of Harbour Commissioners.—The Board of Harbour Commissioners of the Port of Charleston consists of 13 members, 7 of whom are appointed by the Governor upon the recommendation of the senate and members of the house of representatives from Charleston County, while the remaining 6 become members of the Commission automatically by reason of their positions in the city government or other organisations.

Of those appointed by the Governor, at least two shall be seafaring men, of whom one must be a qualified full-branch pilot of the Port of Charleston. The following members of the City Government and other organisations automatically members of the Commission: Mayor of the City of Charleston, President of the Charleston Chamber of Commerce, President of the Charleston Cotton Exchange, Chairman of the Port Utilities Commission, President of the Charleston Young Men's Board of Trade, and the Chairman of the Executive Committee of the State Board of Health, if he be a resident of the city; otherwise some member of the executive committee who is a resident of the city shall be designated by the State Committee. All members of the Board of Harbour Commissioners must be residents of Charleston.

Members of the Board of Harbour Commissions are also designated as Commissioners of Pilotage but under the authority granted to them by law they have vested all of their powers and authority in matters relating to pilotage and pilots in a sub-committee of pilotage. Decisions of the sub-committee, however, may be referred to the Board as a whole.

Publications Received

The Commissioners of the Port of Lancaster have issued a booklet containing a record of historic events connected with shipping using the port in former days. An interesting occurrence dealing with the arming of merchant ships in war-time is recalled in a note referring to an incident of the Napoleonic wars. The note reads:

"1811. February 28th. Captain Greenwood, of this town, was presented by the Underwriters of Lloyd's with a piece of plate value 100 guineas for having made 32 successful voyages to the West Indies, and for having, in the *William Ashton* of this port, mounting 16 nine-pounders and 25 men, beaten off a French corvette of 18-pounders and 125 men."

Rope Talks No. 16 is an attractively illustrated little brochure, which, while mainly explanatory of the varied sources and uses of the products of British Ropes, Limited (Carr Hill, Doncaster), gives much information in an interesting form about the processes of manufacture and the means of transport of hemp and wire rope, together with attractive glimpses of Vancouver Harbour and city, the Bridgewater Canal and other features associated in different ways with the manufacture of rope. We are asked to state that, in consequence of the destruction of their mailing lists through enemy action, the Company invite any reader who has hitherto received a copy of Rope Talks and does not receive No. 16, to communicate with the Editor at British Ropes, Ltd., Anchor and Hope Lane, Charlton, London, S.E.7, so that his name may be restored to the mailing list.

Notes of the Month

Opening of Japanese Joint Harbour.

The formal opening took place on May 20th, of the new Keihin Harbour, which is a combination of the ports of Tokio and Yokohama.

New Danish Fishery Harbour.

The Danish Ministry of Public Works has approved a proposal by the local Fisheries Association for the construction of a fishery harbour at Roevik at an estimated cost of 620,000 kroner.

New West African Harbour.

It is announced that construction of a new harbour at Loanda, Portuguese West Africa, is to be undertaken by an Anglo-Dutch Company. The works include a breakwater or mole, stated to be 330 yards long by 180 yards wide. The harbour will be able to accommodate vessels up to 33-ft. draught.

Knighthood for Port Manager.

Included among the Birthday Honours is the conferment of a knighthood on Mr. John Douglas Ritchie, M.C., General Manager of the Port of London Authority. A biography of Mr. Ritchie was given in the May issue (Notable Port Personalities, No. x).

New Shipbuilding Ways at Melbourne.

The Melbourne Harbour Trust have announced their intention of constructing two shipbuilding ways at the Port of Melbourne, for the building of merchant vessels of up to 9,000 tons deadweight. With the naval construction in hand, the scheme forms the largest shipbuilding project ever undertaken in the State of Victoria.

Wage Increase on the Clyde.

Following the recent award of a guaranteed minimum wage to dock labourers, the Clyde Navigation Trust have agreed to grant increases in pay to cranemen, capstanmen, members of the National Union of Clerks and other workers. The estimated cost for the current financial year is estimated at £6,540 and for a full year £33,960.

New Dry Dock for Philadelphia.

A second dry dock, of the same size as the dock at present under construction, has been authorised by the United States Government for the Navy Yard at Philadelphia, U.S.A. The twin docks, estimated to cost 13 million dollars each, are to be 1,100-ft. long by 150-ft. in width, and will be capable of handling vessels up to 60,000 tons deadweight.

Graving Dock Company's Accounts.

The firm of Grayson, Rollo and Clover Docks, Ltd., of Birkenhead have published their accounts for the year 1940. After deducting all charges, including directors' fees and income tax thereon, provision for taxation and air raid precautions, and adding miscellaneous receipts, the total profit for the year was £51,654. The dividend of 7½ per cent., less tax, recommended is the same as for the three preceding years.

Development of Rhode Island Port.

In connection with the shipment of war material to Great Britain, under the Lease-Lend Act, steps are about to be taken to increase the port and harbour facilities of Narragansett, Rhode Island, U.S.A. The staff of the U.S. Army Corps have been engaged in surveying the navigable channels leading to the port and have submitted a report to the President. It is understood that a considerable amount of dredging is necessary to make the channels available to vessels of large calibre.

Defence of United States Harbours.

An appropriation of 92 million dollars for long range guns, to be mounted along the North-east Coast of the United States, has been made with the view of freeing warships and aircraft from the task of defending the harbours on this seaboard. Major-General Green, in support of the appropriation, told the Committee: " The primary mission of the Air Force is not to defend harbours, but to seek the enemy wherever he may be."

Port Extensions at Mobile.

Extension works are in progress at the Port of Mobile, Alabama, U.S.A., to provide additional accommodation for shipping. These consist of a jetty, 1,250-ft. long, which extends diagonally into the Mobile River, and is provided with wharf frontages on each face, with sheds and warehouses on solid embankment and rail and road tracks in the rear. As the port lies in the Gulf of Mexico hurricane area, the wharf decking is carried at a height of 3-ft. above the highest flood record, and is provided with vents in case the decking should be overflowed. The transit sheds are designed to resist winds of exceptional violence.

Dundee Harbour Appointment.

The Dundee Harbour Trustees announce the appointment of Captain R. S. Boyd as temporary surveyor of cargoes at the port.

Proposed New Floating Dock at Halifax, N.Z.

A report has been circulated in Canada that a new floating dock, capable of accommodating the largest merchant vessel afloat is contemplated at the Port of Halifax, Nova Scotia.

Modernisation of Alexandretta Harbour.

Arrangements are in hand for effecting modernisation of the Harbour of Alexandretta, in Asia Minor, and equipment is being sent from Smyrna and Istanbul with the view of making the town the main port of Turkey for trade with Great Britain.

Retirement of Bombay Port Official.

Mr. F. A. Borristow, docks manager of the Bombay Port Trust has been granted two years' leave preparatory to retirement and has been succeeded by Mr. M. G. H. Templeton. Mr. Borristow has been 27 years in the service of the Trust.

Proposed Wharf at Portland, Maine.

It is announced that a tanker wharf and six large storage tanks with a total capacity of 840,000 barrels, are to be constructed at the Port of Portland, Maine, U.S.A., in connection with the installation of a 15-in. oil pipe line from Portland to Montreal.

New Jetty at Rapid Bay.

A jetty, 1,600-ft. long, now under construction at Rapid Bay, about 8 miles North of Cape Jervis inside St. Vincent Bay, is expected to be completed by the end of the year. It is designed for the purpose of loading limestone from adjacent quarries at the rate of 1,000 tons per hour.

Dredging Work in Napier Harbour.

Dredging operations to secure a depth of 35-ft. at shipping berths and an over-all depth of 30-ft. are in progress at the harbour of Napier, N.Z. The estimated cost to complete the work given at a recent meeting of the Napier Harbour Board is £27,800, and the date of completion is put at the end of the present year. Up till recently the overall depth has been 26-ft.

Deepening of Philadelphia Port Approach.

In order to afford adequate depth for naval vessels navigating the Delaware River to and from the Philadelphia Navy Yard, the channel is being deepened from 35-ft. to 40-ft. The work involves the removal of about 30 million cubic yards of sand, gravel, clay and mud, and about 165,000 cubic yards of ledge rock which lies in the 4-mile stretch of channel from Eddystone to Marcus Hook, Pennsylvania.

Timber Storage at Calcutta.

The Commissioners of the Port of Calcutta have announced their intention of establishing in the vicinity of the docks a special depôt for the storage of timber, while awaiting shipment overseas. The site suggested is to the East of the Caltex oil installation at King George's Dock. The project will involve the laying of a railway siding to the boundary and the execution of about 3 or 4,000 cubic yards of filling on the low-lying ground, apart from the internal rail tracks and roadways.

Safety Measures at Methil Docks.

Safety measures are to be introduced at Methil Docks in an effort to reduce the number of black-out drowning accidents. During the last two winters over 30 seamen and dock workers have lost their lives at the docks in black-out drowning accidents, and over 100 have been rescued.

The owners of the docks, the London and North Eastern Railway, have now agreed to put specially-shaded guide lights at suitable points, guard rails at certain corners, and to paint the quayside edges white.

Arctic Navigation and the Port of Murmansk.

On his arrival in Moscow from leading an air expedition to the Arctic, where Wrangel Island was used as a base, M. Cherevichny, the Russian pilot reports that observations in the Eastern section of the Arctic circle have established the average depth of this part of the Arctic Ocean to be about a mile and two-thirds. The waters of the Pacific were found not to penetrate to the Arctic Ocean, not even in the Eastern part. The warm currents of the Atlantic, however, do enter the Arctic.

Not the least trace of land has been found in the hitherto inaccessible polar zone. The observations of the expedition will have practical importance in connection with the project for the establishment of regular navigation between Murmansk and other European Russian ports and ports on the Pacific.

Methods of Excavation Work at Home and Abroad

By WILLIAM BARNES, M.I.Mech.E.

INTRODUCTION.

I AM GRATEFUL for the opportunity, afforded me by the Council of The Institution of Civil Engineers, to address members and students on excavating machines and their application to many of the world's largest projects involving the use of excavating machinery.

Taking the broad view, it is doubtful whether any class of machinery is playing a more important part in world progress than are power excavators. In their early stages they were used only on public works, chiefly in the construction of railways, docks, harbours and canals; but although many are still being used for this class of work, probably more are being employed to excavate materials removed from the earth's crust, including limestones, chalk, and clay for cement; clay for bricks, tiles, pottery, etc.; minerals, including iron, manganese, copper, tin, and gold ores; non-metalliferous minerals and rocks of all descriptions; gravel and sand for use in many ways; and coal from shallow deposits. The foregoing is in addition to many uses on construction work, drainage and irrigation schemes, etc.; in fact, practically every job in which "muck shifting," to use a well known public works term, is involved.

I do not propose to take up your time by tracing the developments from the spade, shovel, and plough to crude manual and horse-operated pieces of excavator mechanisms on to larger and more elaborate pieces of machinery, powered first by steam engines and latterly by internal combustion engines and electric motors.

It can be safely said that, although started on the drawing board, excavating machinery is developed and perfected in the field. The late Sir Henry Japp, K.B.E., M.Inst.C.E., in his Lecture to Students on the 19th December, 1934[1], brought this point out very ably.

The extraordinary progress made during the past 20 years or so has been due to the ceaseless collaboration of users and makers. Sometimes the user has forced the hands of the maker, and sometimes the maker has anticipated the requirements of the user, so that it is doubtful whether any other class of machinery has been developed to such a high degree of perfection as the result of field experience.

Some of you will be aware of the many different types of excavators that are available, but it may be useful to summarise them as follows:—

The Grab or Clamshell, probably the oldest type of all, is used chiefly for dredging material from below water, and for re-handling materials of all descriptions from stock-piles, etc. It can be used as a land machine or mounted on a pontoon.

The Endless-Bucket Excavator and Dredge is, in principle, almost an old as the grab. It is used for both dry land and under-water excavation, although it has been replaced to some extent by the dragline. It is still, however, supreme as a placer dredge for suitable gold and tin deposits. It is also available in small sizes mounted on caterpillar tracks, for excavating trenches.

The Suction or Hydraulic Dredge is essentially an under-water excavator for dealing chiefly with sand, silt, etc.

The Dipper Dredge is also used for under-water work. It is a single-bucket excavator and will deal with materials too compact for endless-bucket and hydraulic dredges, draglines, and grabs.

The Power Shovel.—Omitting the grab, this is the earliest type of single-bucket excavator, and until recently it was the type most generally used.

The whole of the cutting or digging power is concentrated on one bucket, firmly held to its work, and for this reason it will dig very heavy material without the assistance of explosives, including boulder clay and stratified and jointed rocks. Compact rocks and minerals can also be excavated if they are first loosened by means of explosives. It is obtainable in many sizes, ranging from ¼ cubic yard to 33 cubic yards capacity, with varying boom-lengths to suit the required digging height or dumping radius. Specially compact models are also available to use as "tunnel shovels." It is the most suitable type of excavator for use in rock quarries and open-cast mineral mines. The larger types, known as quarry shovels, are available with buckets of up to 5 cubic yards capacity, having approximately 40 tons digging or cutting effort on the teeth; this affords some indication of their enormous digging power.

The Dragline is now one of the most widely-used types of single-bucket excavators. It has largely replaced the power shovel on many jobs, because normally it stands on the surface of the excavation and digs below its own level, whilst the long booms which can be fitted result in very wide digging and dumping ranges. It is available with buckets ranging from ¼ cubic yard to 20 cubic yards capacity, and with booms up to 250-ft. in length.[2]

Dragline Scrapers or Slack-Line Cableway Excavators and Tower Excavators. These utilise a special type of dragline or bucket or scraper operating on a long cable stretched either between two towers or from one tower and a tail anchor. They are used chiefly for sand and gravel excavations or for building up levees, such as those on the big Mississippi river reclamation schemes, although on these schemes they have been superseded largely by dragline excavators.

The Drag-shovel is a single-bucket excavator available in sizes of up to about 1½ cubic yard bucket capacity, and combines certain advantages of the dragline and the shovel. It digs below its own level and because, like the shovel, the bucket is held firmly to its work, it will dig heavier material than will a dragline of equal size. It is largely used for digging trenches for pipelines, etc.; its digging depth is limited to about 18-ft.

The Skimmer is a small single-bucket excavator with a long, more or less horizontal digging action or travel. It was developed chiefly for shallow cuts on road work, and one of its advantages is that it will leave a clean level floor.

Loaders are used chiefly for loading sand, gravel, crushed stone, etc., from stock-piles, and may be fairly included among excavating machines. At one time they were available only with light buckets mounted on an endless inclined chain, the material at the foot of the heap being usually fed to the buckets by mechanical means, usually rotary feeders. They have been replaced to a large extent by small power-shovels, some of which are built around the power-unit and mounting of agricultural tractors. There are also several types of loaders built very low for use in underground mines.

Tractor Equipment is the latest important addition to the many types of excavating machinery: it includes graders, scrapers, bull-dozers, and bullgraders or angledozers drawn by tractors fitted with caterpillar or self-laying tracks.

Graders are the oldest form of this type of equipment. In principle a grader consists of a long-angled blade supported on a framework mounted on wheels and drawn, formerly by horses, but now by tractors. Such machines are used chiefly for levelling and grading "dirt" roads and for making drainage-ditches alongside the roads. Some graders, known as elevating graders, feed the excavated material on to an inclined belt, which discharges the material into a wagon at the rear of, or alongside, the machine.

Recently, because more power has become available, and because they are more controllable, bulldozers and bullgraders fitted to the front of caterpillar-mounted tractors have practically replaced the older type of grader. The bulldozer and bullgrader can be set at any desired angle to discharge the material to the side of the outfit, whereas the bulldozer is set squarely across the front of the tractor.

Scrapers have largely superseded the elevating grader with its accompanying wagon. They are mounted on two or four large pneumatic-tyred wheels and are drawn by powerful caterpillar-mounted tractors. In principle a scraper consists of a bowl or body which digs, loads, carries, and dumps suitable material. They are made in a wide range of standard sizes, from 2½ cubic yards to 30 cubic yards bowl or body capacity, whilst recently scrapers of 45 cubic yards capacity have been placed on the market.

It will be realised that a wide choice is available to meet almost any working conditions. Sir Henry Japp dealt very ably in greater detail with most of the foregoing equipment in his lecture.[3]

This brief survey of the many types of excavating machines will make it easier to follow the trend of excavator development and progress upon many large schemes involving the use of this class of machinery, commencing with canals, many of which are very much in the news at the present time.

CANALS.

It is safe to assume that without the use of excavating machinery it would have been impossible to construct the many large and artificial waterways of modern times. It is an easy matter to estimate, for many straightforward excavating jobs, such as the Suez Canal, how many men would be required to complete the scheme in so many years, based upon theoretical "man-hours," but it is a different matter altogether to control, house, feed, and look after the health, sanitary arrangements, etc., for tens of thousands of men herded together in inaccessible and probably unhealthy places.

*A Portion of the Dugald Clerk Lecture, 1940, delivered to the Institution of Civil Engineers and reproduced by permission from the Institution Journal.

[1] "Modern Methods and Plant for Excavations." Institution Lecture to Students, Session 1934-35.

[2] William Barnes, "The Dragline Excavator." Journal Inst.C.E., vol. 14 (1939-40), p.8 (March, 1940), also "The Dock and Harbour Authority," September and October, 1940.

[3] Loc. cit.

Methods of Excavation Work at Home and Abroad—continued

The Suez Canal

The forerunner of modern artificial waterways, the Suez Canal, forms an example. It is recorded that small canals were cut across the Isthmus as far back as 600-500 B.C., but it is also recorded by Herodotus that Necho (609-593 B.C) attempted to connect the Red Sea and the Bitter Lakes, but abandoned the work after 120,000 Egyptians had perished in its execution.

Even Ferdinand de Lesseps, whose name will always be associated with the Suez Canal, failed in his first attempt to carry out the work, mainly by means of hand labour, after spending nearly £8,000,000, which he estimated would be the total cost of completing the canal. The work was commenced in 1859, with the assistance of an army of 30,000 labourers provided by the Khedive of Egypt. At the end of two years, however, less than one-fifth of the canal had been cut, which means that it would have taken about 100 years to complete the canal at that rate of progress. De Lesseps was, however, successful in raising rather more than another £8,000,000 and purchased many endless-bucket excavators, dredgers, and transporters, so that hand labour was reduced as much as possible. As a result, the canal was completed and opened to traffic in 1869, ten years after it was started.

Many of the dredgers were fitted with long inclined-shoots, down which the excavated material was washed, by means of streams of water fed into their upper ends, on to the adjacent land clear of the canal embankments. This method of working was the forerunner of the present successful method of discharging material from suction or hydraulic dredgers by means of long pipe lines, some of which are thousands of feet in length.

De Lesseps' original plan was for a canal about 160-ft. wide at the bottom, but the cost proved so high, and the progress so slow, that it was decided to reduce the width to 76-ft., and to provide stations or sidings to allow ships to pass; 80 million cubic yards of material was excavated and the total cost was about £16,500,000 or more than twice the original estimate.

Latterly the canal has been increased considerably in width and depth, by means of large floating bucket dredgers, to enable two ships to pass safely without resort to stations or sidings. The canal is now, in fact, been made to the width originally contemplated by de Lesseps, but later revised by him because of the cost.

The Manchester Ship Canal

This was the next big canal of importance to be constructed. Although it had been suggested 200 years ago, Mr. Daniel Adamson, in 1882, was the first to consider it seriously, and so rapidly did his idea take shape that in 1883-4 Parliament was asked to sanction the scheme.

There was considerable opposition from Liverpool and from the railway companies, which thought their interests would suffer; but in 1885 Parliamentary sanction and the royal assent were obtained.

The Manchester Ship Canal Company was then formed, with a capital of £8,000,000—the same amount, by the way, as for the Suez Canal. The contract was awarded to Messrs. Lucas & Aird for £5,750,000, to be completed in 4 years; they withdrew, however, and Mr. T. A. Walker took it over on the same terms. The first turf was cut on the 11th November, 1887.

Two years later, when all the sections were well in hand, Mr. Walker died. His executors carried on for 12 months, but were then unable to complete the contract. The Ship Canal Company then assigned the work to several contractors, including Sir John Jackson and Mr. C. J. Wills, who signed contracts in 1892. The job was finally completed in 1893, six years after the first sod had been cut—an excellent performance considering the great difficulties which had been unexpectedly encountered.

A 6 W Bucyrus-Monighan on the Albert Canal, Belgium.

Before Mr. Walker's executors gave up it was evident that the original estimate would be entirely inadequate, and the eventual cost was more than £15,000,000, or nearly twice the original estimate.

The dimensions of the canal are as follows:—total length, 55½ miles; average width at water-level, 172-ft.; minimum depth, 28-ft.

Machinery was very extensively employed, and the number of employees on this scheme never exceeded 17,000. The equipment comprised 228 miles of contractors' railway tracks, 173 locomotives, 6,300 wagons, 124 steam cranes, 192 steam engines, and 107 excavators, including 71 Dunbar and Ruston steam navvies of the old tower type, 19 steam crane navvies, built by Whitaker Brothers, of Horsforth, near Leeds, and by John Wilson, of Liverpool, 4 French endless bucket excavators, 3 German Lubecker endless bucket excavators, and 10 dredgers.

In all, 53½ million cubic yards of material was excavated, including 12 million cubic yards of sandstone and 3 million cubic yards taken out by the dredger. The rate of excavation ranged from 700,000 to 1¼ million cubic yards per month.

It is interesting to know that the Manchester Ship Canal was really the birthplace of the full-circle shovel, then called the steam crane navvy. Even now the steam crane navvy is often referred to as the "Jubilee Navvy" because its introduction coincided with the jubilee year of Queen Victoria. When first introduced it was simply an excavating equipment attached to a standard steam crane.

Most of the material from the excavators was loaded into side and end tip wooden wagons, which were specially constructed for use on this contract. The capacity of 4½ cubic yards was fixed so that they held two bucket loads of material from the 2¼ cubic yard heaped capacity buckets used on the old Ruston steam navvies. This heavy and cumbersome type of wagon has been largely superseded in recent years by lighter and more easily-handled steel wagons.

Methods of Excavation Work at Home and Abroad—continued

The Panama Canal

The history of the Panama Canal also goes back a very long way. Following the landing of Columbus on the Isthmus, Alvero de Saavedra, a Spaniard, prepared plans, in 1513, for a canal, without result. For upwards of 400 years the question was considered by various nations, corporations and individuals, but nothing tangible resulted.

The first real attempt was made in 1881 by de Lesseps, fresh from his Suez triumphs, who persuaded his countrymen to invest their savings in a company for cutting a sea-level canal through the Isthmus. Work was commenced in 1882, in the belief that the canal would be completed in 8 years. Tremendous difficulties were, however, encountered, due to heavy and treacherous material and last, but not least, unhealthy climatic conditions. Money also became difficult to obtain, and finally the company was put into the hands of a Receiver in 1889, six years after the work had been started.

The job dragged on and many experts, both Europeans and Americans, were called in to advise on the scheme. De Lesseps contemplated a sea-level canal; but when the immensity of the undertaking was discovered, a lock-canal was suggested, and many arguments were advanced by the experts in favour of one type or the other.

About this time the United States realised the national necessity of a canal through the Isthmus, and an alternative route was surveyed for a rival canal through Nicaragua. In the meantime the Panama Canal Company struggled on until no more money was available, when the Panama stockholders, alarmed by the fact that the United States Government contemplated a rival canal through Nicaragua, decided to try to sell out to the United States. The Panama Company asked for £22,500,000, but the United States valued it at only £8,250,000. The Panama Company stood out for their figure, and the United States Commission therefore reported in favour of cutting a canal through Nicaragua. This forced the Company to a decision, and they surrendered to the United States on the latter's terms of £8,250,000.

The United States took possession in 1904, after de Lesseps had worked on the problem for 12 years. Again the vexed question of a sea-level canal versus a lock canal was brought up, and many arguments were advanced by the advocates of one and the other. An international Board of Engineers was appointed to consider the matter, and in 1906 the Board submitted its report. Eight of the members favoured a sea-level canal and five the lock type. This did not settle the matter, however, because when the report was submitted to the Isthmian Canal Commission the majority of the Commission favoured the lock type, and this was eventually decided upon in June, 1906, two years after the Americans had taken possession. Even after the canal was started further agitations arose because of the huge slips of material, which caused the engineers who were in favour of a sea-level canal to assert that these were only the forerunner of trouble if the suggested scheme of locks was carried out. The lock scheme was, however, continued, and it was decided that the locks should have a length of 1,000-ft. and a width of 110-ft.

Referring now to the excavation work, the French, during the time they were on the job, excavated 78 million cubic yards, including 18½ million cubic yards from the Culebra Cut, 8½ miles long, which at one point was 193-ft. above sea level and was undoubtedly the largest and most difficult part of the scheme.

When the United States authorities took over, they continued to use the old French plant, but took immediate steps to order more up-to-date and more suitable machines and to organise everything on a much larger and better scale than the French had done. They found a small force of West Indian labourers, with a few French officials and engineers in charge—fewer than 1,000 men in all; this force was increased gradually to 3,500 in the first year, and to a maximum of approximately 40,000 in 1913.

During the first year or two labour was brought from the United States, but whilst the pay was attractive, living conditions were so atrocious that a large proportion of those who came returned immediately. It was then realised that in order to secure sufficient men it was necessary to offer not only still higher wages, but also better living conditions, and this problem was thoroughly tackled. Malaria, or "yellow jack," was one of the scourges, but this was eliminated by a concentrated attack upon the mosquitoes and their breeding grounds within the canal zone; without doubt, this was one of the factors which enabled the scheme to be brought to a successful conclusion.

All of the officials, superintendents, foremen and clerical staff (the "gold force") were Americans; during the construction period they numbered rather more than five thousand. Most of the unskilled labour was recruited from the West Indies and other islands; this and the remaining labour was known as the "silver force."

The excavators used by the French consisted entirely of endless-bucket excavators, but large cableways extending right across the Culebra Cut were also employed, the buckets of which were filled by hand labour and then drawn to the side of the cut and dumped into cars.

The Americans soon found that the excavating machinery used was inadequate and unsuitable for the job, and steps were taken to replace the endless-bucket excavators by the heaviest and latest railroad-type steam-shovels, so called because they were mounted on regulation bogies to run on 4-ft. 8½-in. gauge, with outriggers at the front to give the necessary stability when digging across the corners and at the sides: one hundred and two steam excavators were employed, five fewer than on the Manchester Ship Canal, although those on the latter canal were smaller. Seventy-seven were made by the Bucyrus Company, twenty-four by the Marion Company, and one, a full-circle steam-shovel, by the Thew Company.

Most of the excavation in the Culebra Cut was rock, which necessitated extensive drilling and the use of explosives. The Americans discarded all the French steam-drills and substituted up-to-date tripod air-drills and churn or well-drills. More than two hundred churn-drills were used at various points along the canal, chiefly in the Culebra Cut. All were equipped with steam engines and boilers for drilling holes 5-in. in diameter and 100-ft. deep. Many of the drills in the Culebra Cut were, however, operated by compressed air, the boilers being used as air receivers, and the engines being run by means of compressed air. The largest steam-shovel had a 5 cubic yard bucket for digging ordinary material, and a 4 cubic yard bucket for use in rock.

Some of the big shovels, driven by skilled American operators, produced very large outputs, and every encouragement and incentive was given to them to do so. Carefully-compiled records were made of the outputs from the various machines, and it was the privilege of the record-holder each week to fly a broom from the top of the A-frame. The highest daily output for 8 working hours was achieved by a 5 cubic yard shovel which excavated 4,465 cubic yards, an average of 558 cubic yards per hour. The highest monthly output represented an average of 330 cubic yards per hour. In order to secure such results, the shovels were worked to the limit of their capacity, and much useful information was derived from the field experience thus obtained.

The steam-shovels loaded the excavated material on to or into steel cars of 12 and 18 cubic yards' capacity, specially designed and constructed for work on the canal. More than nine hundred of them, supplied by the Western Car Company, were "two-way air-dump" cars, which could be dumped on either side by means of compressed air cylinders situated under the cars and operated by compressed air from a locomotive. Large flat cars without sides were also used, and these were discharged by means of an unloading plough, which was hauled along the cars by means of a cable, operated from a steam winch mounted on a special car at the front of the train, behind the locomotive which supplied the necessary steam.

After the cars had been loaded, they were taken to a large marshalling yard, where they were made up into trains and hauled to one or other of fifteen large dumping grounds, which had a capacity of 50 million cubic yards. A total of more than 109 million cubic yards of material and dumped as spoil. Mechanical spreaders were used, by means of which the material was pushed over the dump, clear of the tracks, before the arrival of the next train. As the dump progressed, mechanical track-shifters were employed to move the tracks nearer to its edge.

In the Culebra Cut, nearly 100 million cubic yards of material were excavated by the Americans; about 25 per cent. of this was due to slides. The cut was 300-ft. wide at the bottom and about 2,000-ft. across the top at its widest point.

The sides of the canal were by no means uniform, as they were sloped to suit not only the depth of the cutting but also the nature of the material. Portions of the slopes were made almost horizontal in an endeavour to avoid the continual slips or slides, which caused great trouble, not only during the progress of excavation, but also later, when the canal was thought to have been finished.

The first ocean steamer passed through the canal on the 3rd August, 1914, just ten years after the Americans took it over. Owing, however, to the slides and to the clearing up of various other odd jobs, it was not opened to traffic until about the middle of 1915.

During the cutting of the canal, and when it was realised what a menace the slides would be, two huge dipper dredgers were ordered to cope with the situation which might arise when the water was let in. They were built by the Bucyrus Company, and are the largest steam dipper-dredger over constructed[4]. The dippers have a capacity of 15 cubic yards, and the machines will 50-ft. below the surface of the water. The dippers alone weighed 22 tons, the dipper-arms 36 tons, and the booms with fittings more than 50 tons. They were exceedingly powerful and dealt regularly with rocks weighing from 20 to 20 tons each. One rock, in fact, weighed more than 50 tons, but the power of the dredge was so great that the operator did not know that he had "hooked" it until it appeared above the surface of the water.

[4]Since then the Bucyrus-Erie Company has constructed a slightly larger Diesel-electric dredge of 1,440 horse-power with a 15 cubic yard dipper with a bale pull of 155 tons to excavate to a depth of 52 feet, for use on the Hudson River.

Methods of Excavation Work at Home and Abroad—continued

In spite of the huge size of the dipper with its load, it was possible for these machines to make a complete cycle of operations in 45 seconds. The dipper dredges were so successful that a third was ordered to deal with the slides, which, on several occasions in 1915, completely blocked the canal.

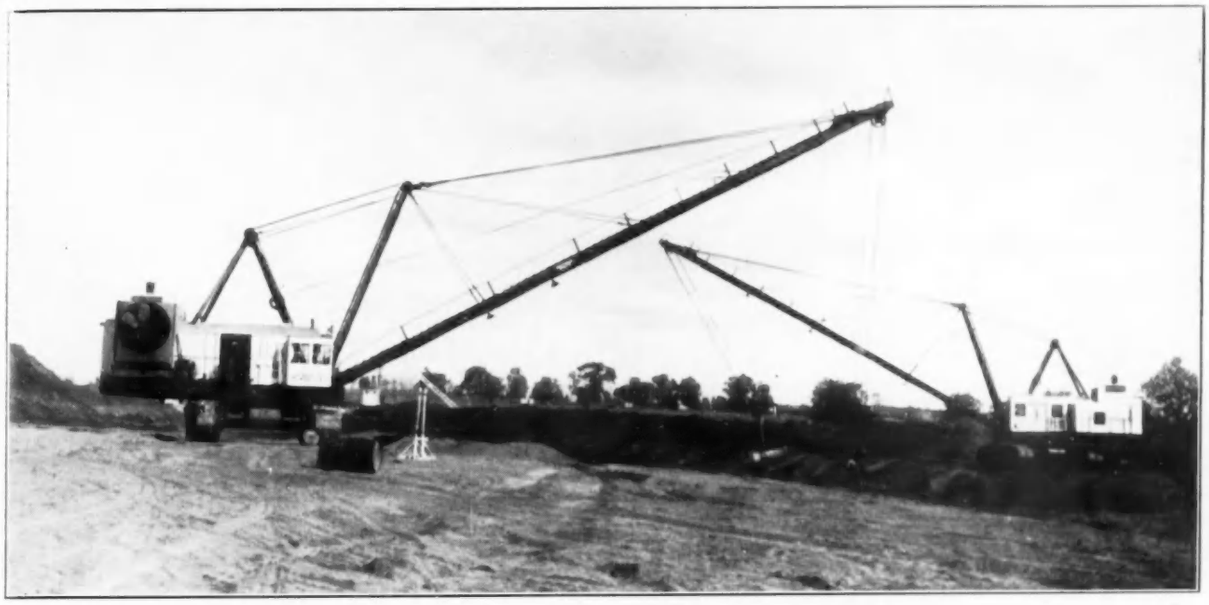
Some of these slides came up from the bottom of the canal, and on one occasion a dredge found only 20-ft. of water where 45-ft. had existed 5 minutes earlier. Furtunately the spuds had been lifted, and the dredger was able to move hurriedly away—just in time, for in less than an hour after the upheaval had been noticed an island appeared. If that had not been seen in time, the dredge would have been stranded and probably wrecked.

Very large outputs were obtained from these machines. The highest recorded in 1915 was 17,185 cubic yards in 24 hours, that is, an average of 716 cubic yards per hour. This was later beaten by the third dredge, which excavated 23,305 cubic yards in 25 hours—an average of 971 cubic yards per hour, including all stoppages, or of 1,002 cubic yards per hour of actual working time.

Even when the canal was opened to regular traffic, slides and upheavals occurred frequently, and the dredges were rushed from one place to another in order to clear the slides and maintain the canal open to traffic.

The total cost of the canal up till the time it was opened to traffic was approximately £78,000,000.

The total quantity of excavation up to the 31st March, 1915, was approximately 232½ million cubic yards, including 78 million excavated by the French and 25 million due to slides.



Two Bucyrus—Erie Caterpillar Mounted Draglines on the Mulwala Canal, Australia.

The Albert Canal, Belgium

The Albert Canal is the largest and most important ship canal constructed during recent years. It connects the port of Antwerp with the large industrial city of Liège, and was intended also to assist in the development of the new coalfields in the Campine basin, north of Liège, and to compete with the modern Dutch canals for the traffic from Liège, about 60 per cent. of which went to Rotterdam instead of to Antwerp. It was further intended as a link in the Belgian national defence scheme, but in this respect it did not prove very effective.

A canal system from Antwerp to Liège had been in existence for many years. This was 96.3 miles long and included twenty-three locks; it could accommodate only comparatively small boats of about 450 tons displacement, and from 12 to 20 days were required to complete the journey. The new canal is 20 miles shorter, and only six locks have to be negotiated to adjust the difference in water levels of approximately 180-ft. Each set of locks consists of two large locks to take one boat of 2,000 tons, or four boats of 600 tons, and one small lock for the quick and economical handling of boats of up to 600 tons. The journey through the new canal can be completed in 4 days.

The canal has a bottom width of 85-ft. 3-in., a depth of 16-ft. at the centre and 11-ft. at the sides: approximately 100 million cubic yards of material were excavated. Its construction gave direct employment to about ten thousand men, in addition to thousands more employed in cement works, quarries, industrial works, etc.

Parts of the canal pass over low-lying ground, upon which it was necessary to build impervious embankments involving more than 35 million cubic yards of filling. In other places the canal passed through three high hills, which necessitated cutting ranging up to 200-ft. in depth and up to 610-ft. in width across the top. These heavy cuttings required the excavation of 32 million cubic yards of material, 50 per cent. of which consisted of tufa, a sedimentary rock.

The route was surveyed and reported upon in 1927-1929; work was started upon it in 1930, and was completed in 1939. The work was carried out by several large Belgian public works contractors on behalf of the Belgian Government. Some of them utilised existing excavators and plant, but a considerable amount of new machinery was purchased.

Draglines and grabbing cranes were used to take out the material for the locks. Upon one section, where a certain amount of under-water work had to be executed, a suction dredge of 300 horse-power and an endless bucket dredge of 150 horse-power with buckets of 7 cubic feet capacity were used, together with a number of grabbing cranes.

Most of the material in the wide sections of medium depth was excavated by means of the following machines:—

1. A Bucyrus Monighan walking dragline with a 6 cubic yards bucket and a 135-ft. boom, powered by a Diesel engine of 280 horse-power, and weighing approximately 300 tons. It was in use for 4 to 5 years, working 24 hours per day (three shifts of 8 hours each) during most of the time, and excavated about 5½ million cubic yards of material. Its normal output was 200-300 cubic yards per hour. Over one period of 17 months it excavated nearly 1¾ million cubic yards in 9,740 hours, with an actual digging-time of 7,940 hours.

2. A Marion Diesel-electric dragline, weighing 164 tons, with caterpillar mounting and a bucket of 3 cubic yards capacity on a boom 110-ft. long. This machine had a normal output capacity of about 150 cubic yards per hour.

3. A large steam endless bucket excavator weighing about 200 tons and fitted with twenty-eight buckets, each of 12 cubic feet capacity. The output capacity of this machine was about 250 cubic yards per hour.

One deep cut in quicksand, etc., was, after careful drainage, successfully dealt with by elevating graders and tractors and caterpillar-track dump-waggons.

Bulldozers gave valuable service on the fills, which had to be compacted by repeated rolling with rollers and caterpillar-mounted tractors.

In addition a large fleet of about twenty-five steam, petrol, and Diesel-engine driven excavators were used, including draglines, shovels, and grabbing cranes, of from ½ to 1¼ cubic yard bucket capacity. Three small endless bucket machines were also used.

More than a hundred locomotives were employed, about half of which were of 1-metre gauge or less. More than a thousand tipping wagons were used, most of 5-6 cubic yards capacity. A number of 13 cubic yard dump cars, arranged for dumping on either side by means of compressed air cylinders, were also employed.

The plant used on the job would doubtless have been more standardised but for the fact that the work was let in several sections to different contractors, who utilised much of their existing equipment. Nevertheless it was an interesting job, because much modern machinery was used, including the tractor equipment, the walking dragline, the Diesel-electric dragline, and a number of smaller Diesel-engined draglines and grabbing cranes.

Methods of Excavation Work at Home and Abroad—continued

Sukkur Barrage and Irrigation Scheme

I now turn to another big canal scheme; not a ship-canal, but for the purpose of irrigating 6½ million acres of land in the Sind desert, in North-West India. This is officially known as the Lloyd barrage and canals construction scheme, and is the largest irrigation scheme in the world, involving the excavation of more than 210 million cubic yards of material.

The purpose of the scheme is to obtain a perennial supply of water from the River Indus, one of the largest rivers in the world, which has its course in the Himalayas 20,000-ft. above sea level in the remote Tibetan plateau. The scheme is centred at Sukkur, about 1,000 miles from the Himalayas, 400 miles from the mouth of the River Indus, and about 400 miles north of Karachi.

For three months of the year ample supplies of water come down the five tributaries of the Indus, the Jhelum, Chenab, Ravi, Beas, and Sutlej rivers from which five rivers the Punjab takes its name; but for 9 months there is a scarcity of water. A dam, nearly 1 mile long, with 46 sluices, each of 60-ft. span, was therefore built across the river at Sukkur, to retain huge supplies of water for distribution by means of extensive canal systems at any period of the year.

The sizes and lengths of the canals are astonishing. There are seven main canals, four on the left bank of the river and three on the right, all situated near Sukkur. These have a total length of about 1,000 miles and range from 79-ft. in width and from 4-ft. to 20-ft. in depth. One, the Eastern Nara, is 525 miles long and 346-ft. wide at the head. In low places " borrow-pits " had to be excavated to build up the canal banks in order to obtain a sufficient depth of water.

In addition to the main canals there are more than 700 miles of branch canals and 4,600 miles of distributory canals, whilst 50,000 miles of final feeders have been excavated by the farmers who rent the land. The material consisted maining of sand and sun-baked clay.

The whole of the canal excavations was carried out by means of forty-six dragline excavators of various types and sizes, as follows:—

- nine large steam draglines with booms ranging from 100-ft. to 145-ft. in length, carrying buckets ranging from 6 to 10 cubic yards capacity, depending upon the boom-length;
- two Diesel-electric draglines with booms 125-ft. long and 3 cubic yard buckets;
- two steam draglines with booms 80-ft. long and 3 cubic yard buckets.
- three steam draglines with booms 80-ft. long and 3 cubic yard buckets.

All of these machines were used chiefly on the construction of the main canals.

For the distributory canals the following draglines were used, all of them " straight Diesel " that is, powered by Diesel engines and operated by clutches:—

- nine with booms 45-ft. long and buckets of 1½ cubic yard capacity;
- sixteen with booms 40-ft. long and 1 cubic yard buckets;
- two with booms 35-ft. long and 1 cubic yard buckets;
- three with booms 35-ft. long and ⅞ cubic yard buckets;

In addition to the draglines, two large suction dredges were employed on the excavation required for the construction of the main dam or barrage at Sukkur.

Most of the machines were operated by natives and Anglo-Indians with a European in charge of each group of machines.

Owing to the desert conditions, working and living conditions were very unpleasant, the sand and sand storms in particular causing considerable trouble to both men and machines, whilst the supply of suitable water for the boilers and the servicing of the machines far away from workshops and sources of supply added to the difficulties.

There were practically no roads in the desert, and tramway tracks from remote railways had to be laid to supply the excavators with the necessary supplies of coal, oil, and stores; whilst some of the smaller machines were so far out in the desert that all supplies, including fuel oil, drinking water, food, etc., had to be transported by motor lorries, bullock carts, or camels. The more isolated units had to rely entirely upon camel transport, and the operators had to live in tents adjacent to the machines.

All of the machines worked three shifts per day, summer and winter. During the summer, and especially in May and June, the temperature at noon was seldom lower than 115° F. in the shade, and was sometimes as high as 125° F., accompanied by sand storms.

The scheme was commenced in 1923, and the first excavators were installed in 1925. The whole scheme was completed and opened in 1932 by the Viceroy of India, so that it was finished in about 8 years, a result to be proud of for a job of this description. The excavation costs, per cubic yard, including labour, fuel, spares, and repairs, but not including capital charges, ranged from about 3½d. for the big steam machines to 1.4d. for the small Diesel draglines.

The total cost of the project was about £15,000,000, or approximately equal to that of the Suez Canal and of the Manchester Ship Canal, although four times as much excavation was involved as on the Manchester Ship Canal, nearly three times as much as on the Suez Canal, and nearly as much as the total excavation on the Panama Canal.

The cost of the dragline excavators amounted to about £800,000, and the total cost of the machinery on the whole scheme, including the two large suction dredges, was about £3,400,000.

Further information in regard to working costs, etc., on this and on other irrigation schemes is given on pages 19-21 of my Paper on " The Dragline Excavator."[5]

Mulwala Canal, Australia

It will be interesting to turn now to a recent irrigation scheme, namely, the Mulwala Canal in New South Wales, Australia, for irrigating about 650,000 acres of land. Its construction was commenced in 1935, and work is still in progress. The portion now under construction is 75 miles long, with a maximum bed-width of 115-ft., a depth of 9-ft., and side slopes of 26 degrees, or 1 in 2. It involves the excavation of 10 million cubic yards of material and the estimated cost is £1,200,000.

The excavating machinery consists of:—

- Four 4 cubic yards Bucyrus-Erie Diesel-engined draglines with booms 73-ft. 6-in. long, extensible to 89-ft. 6-in., with 3 cubic yard buckets.
- One Ruston-Bucyrus Diesel-engined dragline with a 1¼ cubic yard bucket
- One Harman (Australian) Diesel-engined dragline with a 1 cubic yard bucket.
- Two 95 horse-power caterpillar tractors.
- Eight 44 horse-power caterpillar tractors
- One " ripper " for loosening heavy material to enable graders, bulldozers, angledozers, and scrapers to deal with it.
- Two tamping rollers for consolidating the banks.
- Special drag scrapers for trimming the 1-in-2 slopes.

The material includes soft rock, loose limestone, compact clays, and sand. The large draglines are operated in pairs, one on each bank, each pair being worked about 1,000-ft. apart. The slopes are roughly excavated by means of the draglines, and are trimmed finally by means of the drag scrapers, which are operated by 44 horse-power tractors travelling on the top of the banks. The main cuttings are excavated by the four large draglines, whilst the two smaller draglines, and the tractor equipment, are used for the final levelling, cleaning up, etc., and for excavating " key channels " under the banks.

All major repairs are carried out in a large more or less centrally situated workshop, whilst minor and working repairs are executed in a mobile workshop which is moved along with the draglines.

Up to May, 1940, the quantity of material excavated amounted to just over 7 million cubic yards, at a total " all in " cost of 8.309d. per cubic yard, including capital charges, depreciation, supervision, etc. The working costs include wages, 1.602d. per cubic yard; and repairs, renewals, and sundries, 2.366 d. per cubic yard.

In order to reduce the capital charges, and to enable the scheme to be completed within the allotted time, the plant is being operated three shifts daily.

Depreciation was originally fixed at 2.6d. per cubic yard, but in view of the efficient condition of the plant, it is considered that this allowance is excessive, as the machinery will still be in saleable condition when the scheme is completed.

SUMMARY.

From the particulars of the machinery used on the foregoing canal schemes, it is interesting to summarize the progress made in the use of excavating machinery for canal construction.

The Suez Canal was excavated mainly by means of endless bucket excavators, the only type of excavator available at that time. If the work were to be carried out at present there is little doubt that Diesel-engined draglines of the walking type and tractor equipment would be used almost exclusively for the dry excavation, and suction dredgers for the wet.

Upon the Manchester Ship Canal a few endless-bucket excavators were employed, but most of the excavation was done with the old steam navvy with a quantity by early-type steam crane navvies. At present it would probably be carried out by Diesel-engined full-circle shovels, chiefly for the sandstone rock, supplemented by draglines and tractor equipment where the conditions were suitable.

Upon the Panama Canal heavy full-circle quarry-type shovels, electrically operated, would most likely be substituted for the railroad type of steam shovels for most of the excavation, especi-

[5] Loc. cit.

Methods of Excavation Work at Home and Abroad

(continued)

ally in the Culebra Cut, supplemented by Diesel-engined draglines, medium-sized Diesel-engined shovels and tractor equipment.

Upon the Sukkur scheme no useful substitute could be made for the draglines, which were so successfully employed, but Diesel and electric or Diesel-electric power would certainly replace steam power upon the large draglines, as the boilers were a considerable source of trouble and much time was lost, owing to the difficulty of obtaining suitable feed water and of keeping them supplied with the large quantities of coal they consumed. Tractor equipment would also be employed.

The smaller Diesel-engined draglines used on the distributory canals could not be improved upon, as they were ideal in almost every respect.

Notable Port Personalities

XII.—The Rt. Hon. Thomas Wiles, P.C.

The Rt. Hon. Thomas Wiles, P.C., recently elected Chairman of the Port of London Authority, has served on the Board of the Port Authority since 1923, when he was elected as one of the members representing "Goods." He was Chairman of the Authority's Law and Parliamentary Committee from 1925 to 1934 and of the Finance Committee from 1936 to 1940. He has been Vice-Chairman since 1934.

The RT. HON. THOMAS WILES, P.C.

In 1899 Mr. Wiles represented South-West Bethnal Green on the London County Council, and was M.P. (Liberal) for South Islington, 1906-1918. He was Parliamentary Secretary to the Rt. Hon. T. McKinnon Wood (Financial Secretary to the Treasury and afterwards Secretary for Scotland). In 1916 he was sworn a member of His Majesty's Privy Council. He is a J.P. for Oxfordshire and Chairman of the Royal Surgical Aid Society.

Mr. Wiles has many commercial interests in the City of London. He is senior partner in the firm of Joseph Wiles and Son, Ltd., grain merchants; Vice-Chairman of the Corn Exchange; Vice-Chairman of the Anglo-Portuguese Colonial and Overseas Bank, Ltd., and a member of the Baltic Exchange. He was President of the London Corn Trade Association, 1919 and 1920, and President of the National Federation of Grain Trade Associations, 1922-1923.

Mr. Wiles has travelled a great deal. Besides inspecting the leading ports of Europe he has also visited New York, San Francisco, the Panama Canal and the harbours of Monte Video, Buenos Aires and Rio de Janeiro; Cape Town, Port Elizabeth, East London and Durban in South Africa, as well as Colombo, Ceylon, where he studied all their port facilities.

The Association of Consulting Engineers.

Mr. Godfrey M. C. Taylor, M.C., M.A., M.Inst.C.E., of Messrs. John Taylor & Sons, Caxton House, Westminster, S.W.1, has been elected Chairman of the Association of Consulting Engineers for the year 1941-42.

Mersey Docks Administration Changes

The retirement takes place on July 2nd of **Sir Lionel Ashton Piers Warner, C.B.E.,** from the general manager and secretaryship of the Mersey Docks and Harbour Board, a position which he has held for the long period of 21 years. Prior to 1920, he was for six years an assistant to Mr. Alfred Chandler, C.B.E., the former general manager and secretary.

Sir Lionel is 65 years of age; a sketch of his career with a portrait was given in our Notable Port Personalities series in the August issue last year. Briefly summarised, it included education at Marlborough College, followed by 20 years service with the Great Western and London and North Western Railway Companies, in the latter period as chief outdoor assistant to Sir Robert Turnbull, the General Manager.

During the 27 years of Sir Lionel's service with the Mersey Docks Board, some 500 million tons of goods have passed through the port. This has been in spite of the prolonged shipping slump which caused the tonnage in 1921 to fall as low as 15,813,126. On the other hand for the two years immediately preceding the present war, highest records were made, reaching 22,097,755 in 1938. Strangely enough, the number of vessels paying dues in 1921 has never since been equalled—vessels have increased in size, but decreased in number.

Sir Lionel received the distinction of the C.B.E. in 1919 and of a knighthood in 1936.

The vacancy in the administration of the Mersey port has been filled by the appointment of Mr. Reginald J. Hodges, hitherto deputy general manager. He takes over the secretaryship jointly with the general managership. Mr. Mark R. Preston and Mr. Charles Ree have been appointed assistant managers and Mr. R. D. Jackson, assistant secretary. Mr. Hodges entered the service of the Dock Board in 1935, having previously been a director of the Anchor Line, after many years service with the Cunard Line.

Clyde Navigation Engineering Staff

The retirement is announced of **Mr. Alfred Charles Gardner,** M.Inst.C.E., M.I.Mech.E., Engineer to the Clyde Navigation Trust since 1929.

Mr. Gardner commenced his professional career at the Thames Ironworks, where he served his apprenticeship during the construction of three notable battleships: H.M.S. *Albion*, *Duncan* and *Cornwallis*. After some years as an assistant with the London County Council and the Great Western Railway, he was engaged on the staff of the Great Central Railway on bridge construction, and work in connection with the new dock at Immingham.

After employment with the War Office at the beginning of the 1914-18 European War, he was appointed in 1917, Docks Engineer in charge at Grimsby and Immingham. He held the position of Docks Engineer to the Great Central Railway and afterwards to the London and North Eastern Railway until 1929. During this time he carried out the reconstruction of No. 1 Graving Dock at Grimsby, the new Fish Markets and the reconstruction of New Holland Pier, together with extensions to the Power Station at Immingham. He was also responsible for the design and construction of the lift-bridge constructed by the Corporation of Grimsby across the Alexandra Dock.

During his service with the Clyde Navigation Trust, Mr. Gardner, in addition to maintenance work, carried out new constructional operations, many of which are described in a Paper read before the International Engineering Congress in 1938 and published in the issues of this Journal for August and September of that year.

Mr. Gardner was President of the Institution of Engineers and Shipbuilders in Scotland from 1937 to 1939. He was awarded a Telford Premium of the Institution of Civil Engineers in 1934.

In consequence of the retirement of Mr. Gardner, Mr. James Macfadzean, hitherto assistant engineer, has been appointed Chief Engineer. Mr. Macfadzean has been in the service of the Trust since 1920.

Obituary

The death took place on June 7th at the age of 81 of **Mr. Dennis Ross-Johnson, C.B.E.,** who, until his retirement in 1928 had been General Manager and Secretary of the Port of Bristol since 1911. He was also actively interested in the Institute of Transport, of which he was for some years a member of the Council and later, a vice-president. A biographical sketch of Mr. Ross-Johnson's career, with portrait, appeared in the series of notable Port Personalities, No. III. in the October, 1940, issue. He was a welcome contributor on several occasions to the columns of this Journal and had warmly advocated the utilisation of canals and inland waterways for the relief of the congestion at British ports in war time. Mr. Ross-Johnson's work on "Modern Dock Operation" is a well-known text-book.

Goods Handling at British Ports

Select Committee's Recommendations for Increase in Celerity

The Select Committee on National Expenditure has issued its Sixteenth Report of the present session of Parliament. It is obtainable at H.M. Stationery Office (price 2d.) and is of importance to port officials and shipping agents, since it contains a number of recommendations made for the purpose of securing greater expedition in the handling and dispatch of goods at ports. The Report was prepared by the Sub-committee on Transport Services and, while dealing mainly with port operation, it also includes observations on the coal mining industry, with an urgent appeal for strict economy in coal, gas and electricity consumption.

The following extracts are from the section relating to port operation:

Introductory

As a preface to this Report the Sub-Committee think it desirable to make clear that, in seeking to ensure that all proper economy is secured with full value for expenditure, it is necessary to bear in mind an important fact. Where national expenditure is involved in the purchase of armaments of all kinds, investigation necessitates examination into the methods of contracting, efficiency in the use of materials and the employment of labour, and the proper allocation of overhead charges. In dealing with transport and shipping, somewhat different considerations apply. While freight charges, whether sea or railway, are obviously of importance for their effect on the ultimate cost of production, delays in what are transport, and not manufacturing, operations may result in a rise in costs higher than that caused by excessive freights alone. In other words, loss of time may be more serious than increased cost of transport. Yet it is impossible to assess in terms of money value the loss occasioned by transport delays. The avoidance of delay is important in the first place because of its costliness. But delays have other serious consequences, such as hindering production generally, which it is not necessary to elaborate here. Loss of time is therefore a factor which the Sub-Committee have felt bound to keep constantly in mind, and they have considered it their duty to investigate every possibility of securing economy of transport time as being at least equal in importance to securing economy in actual cash expenditure.

Examination at the Ports

Since the issue of the Committee's Tenth Report of the present Session dated 20th March, 1941 (H.C. 71, 1940-41),* the Sub-Committee have visited certain ports and investigated operations on the spot. The opportunity was taken of obtaining further evidence locally on many of the problems and activities involved, as well as on the prospects of the speedier handling of ships' cargoes as the result of the introduction of new schemes for the better control, use and remuneration of dock labour in certain of the ports.

The Sub-Committee think it right to say that considerable improvements have followed the appointment by the Minister of Transport of Regional Port Directors at certain of the ports. This is largely due to there now being an executive authority at these ports from whom final decisions on practically all matters can promptly be obtained. But, apart from this important advantage, the introduction of new methods is undoubtedly resulting in closer co-operation and improved efficiency at the ports. This is to some extent due to the fact that those expert in the various branches of port working have been consulted and their ready co-operation secured. The methods of working differ between one port and another, and it would have been a mistake to endeavour to apply one particular method to all ports alike, notwithstanding the fact that in war-time all ports have come under the jurisdiction of the Ministry of Transport (now merged in the Ministry of War Transport). This error has not been made, and the necessary flexibility has been wisely allowed. The soundness of this policy cannot be questioned. The Sub-Committee, therefore, desire to report that, in general, they can comment favourably upon the economic advantages and improvements which have followed upon the appointment of Regional Port Directors, and of the successful steps taken by them, in co-operation with the Port Emergency Committees, to secure the more rapid turn-round of shipping at the ports.

The New Schemes for the Better Control of Dock Labour

The Sub-Committee have made careful enquiries into the probable results of the introduction of the new schemes for the better utilisation and control of dock labour. They have discussed these fully with representatives of employers, of workers, and with the Trade Union leaders concerned. The views the Sub-Committee have received frequently conflict, but it is recognised that these must remain only as expressions of opinion until the schemes have been in operation for some time, and over periods both of pressure and of slackness of work. Experience alone will prove their soundness or otherwise. It so happened that the introduction of these new schemes coincided with a temporary lessening of high pressure at certain ports; they would undoubtedly have had a more favourable start if, at their initiation, there had been a high demand for labour. In this connection the Sub-Committee ascertained that at one port, because of the temporary reduction in the demand for labour, the system of a guaranteed minimum wage involved the Ministry of Transport at the end of the first week in a payment of a considerable sum for which no service had been rendered. This represents the difference between the guaranteed minimum wage under the new system and the total wage costs which would have been incurred under the former arrangements. It may be argued that these new schemes are more expensive in operation than the old casual system. Given, however, certain conditions, the higher cost may be offset by the greater mobility and efficiency of dock labour. The attainment of this desired result must entail adequate supervision of the men, and the taking of disciplinary action in all cases of unjustifiable absenteeism, bad time-keeping, refusal to accept work or deliberate avoidance of work offered.

There was, however, one view generally held, namely, that the success of the new schemes would largely depend upon the introduction of piecework, carried to the utmost limit of practicability, in the loading and unloading of all types of cargo. The Sub-Committee therefore recommend that every effort should be made to extend piece rates wherever practicable. In so far as it is possible at present to form any opinion, it is the view of the Sub-Committee that, although the new schemes have been introduced as war-time measures only, the adoption of piece rates and the de-casualisation of labour may prove advantageous both to employers and employees, not only during the continuance of the war, but more permanently when peace-time operations can be resumed. Much will depend, however, upon the system of piecework and the agreed rates of remuneration for such work as well as upon the proper observance of their obligations by the dock workers themselves, and also upon the discipline enforced by those responsible for administering the scheme. The most recent evidence received by the Sub-Committee would tend to show that, while the majority of workers are working satisfactorily, some of them are deliberately attempting to evade work so long as they do not thereby imperil their right to receive the minimum weekly wage. It would also appear from evidence that such attempts at evasion of their responsibilities by the workers are not being firmly handled by those responsible for seeing that these obligations are faithfully observed. There are also complaints that inefficiency has resulted from the abandonment of the system hitherto in force whereby certain firms have regularly employed particular groups of dock workers known as "preference men." These "preference men" are accustomed to the methods of their regular employers and their equipment, etc., and it seems unfortunate that such groups which have worked as a "team" should be broken up. In view of these and other complaints, the Sub-Committee recommend that small committees should be set up by the Minister of War Transport at the more important ports to enquire into the report upon the working of the new schemes as soon as they have been in operation for a period of three months, and that until this investigation has been made similar schemes should not be introduced at other ports.

Canteens

In general, there is room at some of the ports for considerable improvement in the number, location, equipment and general amenities of canteens and in the provision of adequate and sustaining food supplies (especially of boneless meat) at these canteens. Better travelling facilities between the places of work and canteens would also be advantageous. The Sub-Committee strongly recommend the appointment of experienced canteen and welfare supervisors where such do not exist at the ports.

Pilferage at the Ports

There is a source of economic loss to which the Sub-Committee with regret feel bound to direct attention. It is a trouble which appears to be prevalent at most, if not all, of the ports, namely, pilferage, particularly of articles of food and drink, and, to a lesser extent, of wireless sets, electric torches, etc. Here and there, small organised gangs appear to have operated, but in general it is widespread and sporadic. The Trade Union leaders are anxious not only to check this practice but also the system whereby the fines imposed upon convicted delinquents are provided by their mates. The trouble is a difficult one to check and eradicate, but the Sub-Committee have found that a common view prevails, namely, that the fines imposed on conviction are too light to deter offenders, and that much heavier penalties should be imposed. It may become necessary to treat these offenders with the same severity as those convicted of looting in war time, for cases have been reported to the Sub-Committee where men have committed thefts after being warned by their employers that on conviction they would not only be dismissed, but deprived of their pension rights. Even these stern warnings and penalties have not deterred some thieves. This matter is by no means an unimportant one, for, apart from the dishonest diversion of food from the use of the general community, these

(Concluded on page 196).

*Vide May issue of "The Dock and Harbour Authority."

Wharf Extension at Newcastle, New South Wales

AT the Newcastle (N.S.W.) Steel Works a 300-ft. extension of the existing timber wharf has recently been completed in reinforced concrete. The work was described by Mr. H. Hughes in an article printed in *Constructional Review*, from which the following notes have been abstracted.

Borings and Test Piles

The test bore results were fairly uniform, an average result indicating that the mud commenced at a level approximately 22-ft. below deck level and was approximately 12-ft. deep, followed by approximately 14-ft. of sandy mud, and then white sand. A hard bluish-grey clay stratum showing occasional small shaley patches was found approximately 48-ft. below deck level, and bores carried down 35-ft. into the clay, or approximately 87-ft. below deck level, gave no indication of any change in formation.

The timber test piles were 60-ft. long, and were driven until a penetration of 10-ft. into the clay stratum was reached, which corresponds to a depth of 23-ft. below dredged level. A safe bearing value of 45 tons per pile was assumed. To ensure against failure or damage to the structure due to subsidence of the filling or underlying stratum, all bearing, sheet, and batter piles were driven to approximately the same penetration of 18-ft. into the clay stratum.

General Arrangement

The new wharf is 300-ft. long and has a deck 47-ft. wide of monolithic beam-and-slab construction, which is supported on transverse rows of bearing piles spaced at 6-ft. 6-in. centres. The piles are in five longitudinal rows (Figs. 1 and 2) with a dividing row of concrete sheet piles between the third and fourth rows of bearing piles. The sheet piles are interlocked to prevent erosion of the shore filling and to stabilise the ground adjacent to the wharf deck. Two rows of batter piles on the river and shore sides of the sheet piles, spaced between the bearing piles at 6-ft. 6-in. centres and driven on a batter of one in three, provide the necessary lateral stability.

The 9-in. deck slab is supported between transverse beams over each row of bearing piles. These beams are tied together by three longitudinal beams, of which one is above the row of sheet piles, one along the front face, and one along the back of the wharf. The two beams above the sheet piles and at the back of the deck were designed to accommodate the rail tracks for a 16-ton electric travelling luffing crane. The front longitudinal beam provides accommodation for double cast-steel mooring bollards, connections for service pipes, etc., as well as attachments and stops for securing the spring fender piles and fenders.

To provide the weight necessary for the resistance and stabilisation of this type of wharf the design shows approximately 4-ft. 6-in. of consolidated sand filling on top of the deck slab, finishing at the level of the underside of the rail sleepers. Underlying all rail tracks, a strip of 1½-in. slag ballast, approximately 9-ft. wide and 12-in. deep, is inserted into the fill. The deck filling is finished with a 12-in. layer of rolled tar macadam brought to the top of the tracks and finishing at the level of the cast-iron chequer plates bolted along the top face of the front wall. Treated ironbark fender piles driven at 13-ft. centres, fitted to double tallow-wood walings, are provided to protect the structure from shocks due to vessels.

Details of Piles

The 478 piles necessary to carry the superstructure required 2,800 cu. yd. of concrete, 200,000 sq. ft. of formwork, and 390 tons of reinforcement.

The bearing and batter piles, numbering 338, have a nominal cross section of 17¾-in. square with 1-in. chamfers to the corners and lengths of 65-ft. and 70-ft. The reinforcement comprises eight longitudinal bars of 1-in. diameter, spaced four in the corners and one in the centre of each side, and caged square about spreaders spaced at 4-ft. centres. Stirrups or binders bent from ¼-in. diameter bars spaced at 2-in. centres at the point and head with 6-in. spacings in the centre of the pile tie the cage together. The reinforcement was designed to give a minimum concrete cover over the steel of 2½-in.

The sheet piles, numbering 140, have a nominal cross section of 24¾-in. by 18¾-in., with 1-in. chamfers at the corners and a length of 67-ft. A tongue and groove with a nominal cross section of 7-in. by 2-in. was formed in the edges of the piles to enable them to be driven interlocked. The reinforcement was similar to that of the bearing and batter piles, the main bars being 1¼-in. and the stirrups 5/16-in. diameter.

File points of cast iron were used on all piles. The bearing and batter pile points were secured with one 1¼-in. diameter ragged dowel cast into the pile, and the sheet pile points by two 1¼-in. diameter bars cast in.

Concrete Vibrators

Owing to the necessity for producing a dense impervious concrete it was decided to use a vibrated slag concrete having nominal proportions of 1 : 1½ : 3. The use of vibrators enabled the quantity of mixing water to be reduced, resulting in the production of concrete having increased compressive strength. The possibility of shrinkage cracks is also eliminated, while the high frequency vibrations ensure good packing of the concrete into the forms and the production of a dense impervious concrete.

Internal pneumatic vibrators were used for this work, the external type first tried not being found entirely satisfactory. The vibrating unit consisted of a high-speed air turbine rotating an eccentrically-loaded rotor at a speed of from 3,000 r.p.m. to 4,000 r.p.m., with an air pressure from 80 lbs. to 100 lbs. per square inch, the whole being enclosed in a waterproof outer casing 3-in. in diameter and 15-in. long, to which flexible air and exhaust lines were attached. The throttle and line oiler were approximately 6-ft. from the vibrating unit, so that the latter could be inserted directly into the concrete mix. In this manner the forms were not vibrated, and the possibility of throwing them out of line was removed.

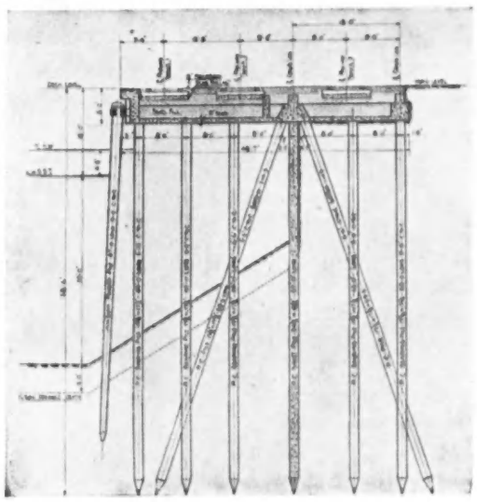


Fig. 1. Typical Section.

Pile Formwork and Casting

The adoption of vibrated concrete required the use of heavier and well-constructed formwork having close-fitting joints to prevent leakage of cement grout from the concrete. The forms were constructed of 1½-in. Oregon pine, covered with 18-gauge sheet iron and built up of bottom and side units. All contact faces of the forms were given a coat of light oil after erection. The reinforcement was built up in cage form and assembled directly above the forms. Care was taken to see that the ends of all main reinforcement bars were set in a plane so that all received equal concrete cover of 2½-in. at the head of the pile. It was thought that this would produce an even distribution of stress in the head of the pile, and so prevent failure during driving. The reinforcement cage was suspended in place of the forms by wires secured to the formwork and held accurately in position by means of timber gauges or strips fitted at intervals between the reinforcement and the side forms. As concreting proceeded the timber gauges were withdrawn, and before the concrete had taken its initial set the suspension wires were withdrawn.

All coarse aggregate consisted of crushed blastfurnace slag, the gradings used being ¾-in. and $\frac{5}{16}$-in. The fine aggregate consisted of beach sand and slag dust. Portland cement was used. The grading to produce concrete having arbitrary proportions of 1 : 1½ : 3 was designed to conform to Fuller's maximum-density curve, and resulted in the proportions of 1 : 1.62 : 2.94, with the fine aggregate consisting of beach sand and slag dust in the proportions of 1 : 1.6 and the coarse aggregate consisting of ¾-in. and $\frac{5}{16}$-in. slag screenings in the proportions of 1 : 1.48. The water-cement ratio was 0.64 and the cement content averaged 7.8 bags per cubic yard.

The concrete was mixed in two 5 cu. ft. tilting drum petrol-driven mixers. Gauge boxes ensured accurate proportions. The mixing water was measured and adjusted by the results obtained from frequent slump tests. Concrete having a slump consistently maintained at 2-in. was found to be most suitable for vibration. Three 8-in. by 4-in. test cylinders were taken from each pile and tested at 7 days and 28 days respectively, the average compressive strength being 3,270 lbs. per square inch at 7 days and 4,160 lbs. per square inch at 28 days. The side forms were stripped 48 hours later.

Seven days after casting, a steam loco crane with a 70-ft. jib lifted the piles and stacked them for curing. They were slung

Wharf Extension at Newcastle, New South Wales—continued

with two 30-ft. 1¼-in. slings protected by bagging. Removable sections provided in the pile-casing beds enabled the slings to be placed around the piles, which were stacked three high for curing, being separated by 10-in. by 8-in. timber packing. This enabled the piles to be cured evenly and efficiently, and also simplified handling them for transport. All piles were designed to be supported at two points, located at distances from each end equal to one-fifth of the pile length. To prevent overstressing and injury to the piles this condition was strictly adhered to during slinging and slacking.

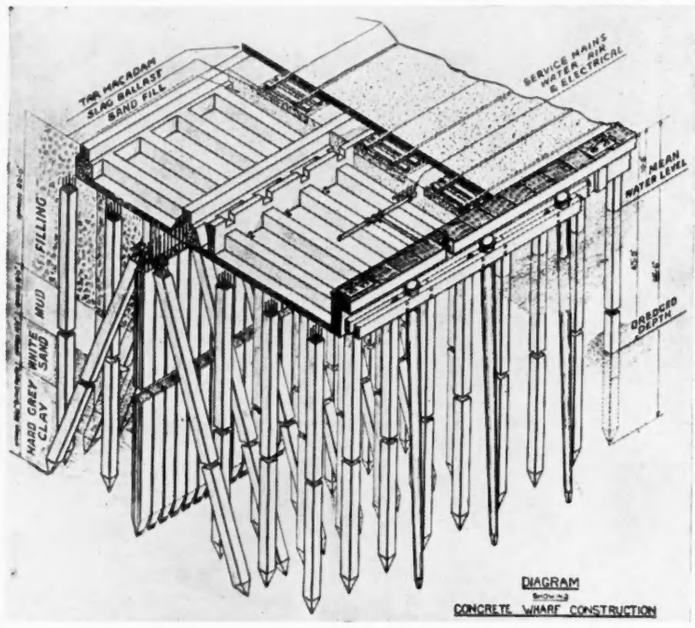


Fig. 2.

The piles were covered with bagging and kept wet for three weeks after casting by means of fine garden spray nozzles set at 6-ft. centres in portable pipes which were moved to suit wind conditions. The sprays were operated only during sunlight hours. Close examination of the stacked piles revealed in some cases the presence of minute hair cracks in the tension faces in the middle of the supported span and directly over the supports. These cracks were so fine that it was reasonably assumed they would be sealed with marine sediment when the pile was not subjected to bending stresses.

Pile Driving

The piles were driven by contract by C. R. McKenzie (Drummoyne) Pty., Ltd. The preliminary work included building temporary falsework to support the piling plant. Timber piles spaced and driven to clear the new concrete piles supported longitudinal timber girders fitted with 60 lb. rails and provided with bracing to stabilise the whole during piling operations.

The piling plant consisted of a timber-framed non-swivelling top carriage carrying an 80-ft. timber-framed tower provided with swinging leaders for driving the batter piles. A vertical boiler of approximately 70 h.p. supplied the power to an 11-B-2 McKiernan-Terry hammer and operated a heavy double-drum friction-operating piling winch and a smaller double-drum winch for operating the jetting gear. The main winch provided the power for cross-traversing the pile frame on an undercarriage constructed of three main girders extending the full width of the falsework, securely braced and fitted with rails to accommodate the pile frame track wheels; while skid plates fitted to the underside permitted the whole plant to be skidded longitudinally on the falsework rails, power being provided by suitable hand winches.

The shore equipment consisted of a pair of sheer legs operated from a vertical boiler and winch, and which spanned the construction railway built parallel to and adjacent to the river bank for the handling of the concrete piles. The McKiernan-Terry double-acting steam hammer was used in the early stages, but was later superseded, except for the driving of the batter piles (Fig. 3), by an 8-ton cast steel drop hammer. The steam hammer was used throughout for driving the batter piles, as it would have required extensive alterations to the pile frame to have operated the 8-ton drop hammer on a batter of 1 in 3. A 4-in. four-stage centrifugal pump delivering 30,000 gallons per hour at a pressure of 120 lbs. per square inch, driven by an 80 h.p. electric motor, provided effective and satisfactory jetting. The pump was erected on the shore. Its efficiency was increased by connecting the suction to the salt-water service with a pressure of 30 lbs. to 40 lbs. per square inch. Two 3-in. relief valves set at 120 lbs. per square inch fitted to the delivery main prevented injury to the two 2½-in. six-ply rubber hoses connecting the 4-in. shore main to the piling plant. Similar rubber hoses were also attached to the two 60-ft. 2½-in. jetting pipes, the latter being nozzled to 2-in. at the delivery.

The piles were delivered on railway wagons and were removed from them by the sheer legs. They were pitched by using a combination of sheer legs and pile frame, each lifting one end of the pile. By hoisting on the pile frame and paying out the sheer leg tackles the piles were transferred from a horizontal position and slung vertically in the frame without shock or injury. Owing to the confined space in front of the salt-water pump-house it was necessary to replace the sheer legs later by a floating piling plant for this operation.

Piling was slowed down considerably in the early stages, owing to the heavy rough filling encountered. Obstructions assumed to be slag skulls or large pieces of broken concrete dumped some years previously, and eventually having penetrated through the mud to the sand level, made it extremely difficult to pitch and drive the piles within the allowable 3-in. tolerance. These obstructions were more numerous at the eastern end of the wharf, where driving operations were commenced, the 1½-in. jets operated by plunger-type pumps then in use proving inadequate to break the suction of the mud and move the obstructions. Where the jets failed to move the obstructions, explosive was effectively used. A 1½-in. pipe with a sealed and pointed end was driven to the required depth, charged with 8 lb. to 10 lb. of gelignite and electrically fired. This also proved the most effective means of breaking the suction in cases where it was necessary to withdraw concrete piles which had been partly driven. In this case it was found necessary to keep the pulling strain on the pile while the charge was fired.

The heads of the piles were effectively protected during driving operations by a 3-in. layer of Oregon timber enclosed in a cast-steel driving helmet with the addition of old bagging placed over the head of the pile. Iron-bark dollies of 15-in. diameter were used to transmit the hammer blows to the helmet, and in cases of heavy driving as many as six dollies were used on one pile. For use with the 8-ton drop donkey a larger dolly was designed, consisting of iron-bark blocks 6-in. long and tightly fitted on end into a heavy square steel frame attached to the driving helmet; each set of blocks was used for the driving of approximately thirty piles.

Before installing the larger jetting pump and using the steam hammer, it was slow and difficult work to drive the sheet piles through the sand layer. In the clay stratum the resistance to driving became less, and a reasonable rate of driving was maintained, the required 18-ft. penetration into the clay stratum being reached with a driving set of approximately 140 blows to 1-ft. The 2½-in. jetting pipes used in conjunction with the 8-ton drop hammer considerably reduced the driving time. The operation of the two jets on opposite sides of the pile, with the nozzle kept near the point, and the weight of the drop hammer resting on the pile, enabled piles to be sunk to the clay stratum in 20 minutes after pitching, the high-pressure jets also ensuring better control and more accurate placing. Using a 3-ft. drop, the final penetration was reached with a driving set of ¾-in. to ½-in. per blow.

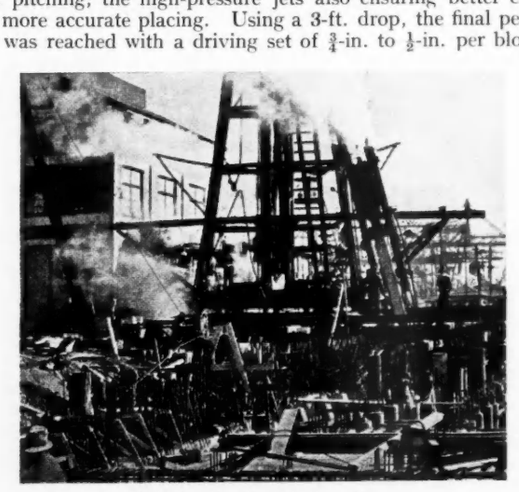


Fig. 3. Driving Batter Piles.

The Superstructure

The pile heads were blown off with explosive to the level required. Several 1¾-in. holes were drilled through the pile at cut-off level, and a chase cut around the pile to the steel. Where the cut-off did not exceed 3-ft. in length a single charge hole 1¾-in. in diameter was drilled in the side of the pile, and a charge consisting of a quarter of an 1⅛-in. plug of gelignite inserted and electrically fired. The amount of explosive shattered the concrete with-

Wharf Extension at Newcastle, New South Wales
(continued)

out causing excessive bending of the reinforcement, which was later straightened for bonding into the superstructure. Where the cut-off lengths exceeded 3-ft., additional similar charges were placed at 3-ft. centres.

The formwork for the superstructure was carried on transverse 6-in. by 4-in. Oregon bearers tightly cramped to the piles and supporting 4-in. by 2-in. joists covered with tightly-cramped 6-in. by 1-in. timber. As vibrators were used for placing the concrete, the whole of the contact surfaces of the formwork were covered with Sisalkraft to prevent the leakage of cement mortar.

The superstructure was formed in four complete sections with three transverse construction joints in the length of the deck. These joints were spaced between pile centres, the continuous deck reinforcement being protected against corrosion by two 6-in. wide strips of 16 oz. copper inserted in the concrete extending across the joint and placed above and below the reinforcement. The concrete was poured continuously in each section. After curing for four weeks, the sand filling was placed in the deck, and the mains for fresh water, compressed air, and electrical services were laid.

Ironbark piles were used for the spring fendering. The piles are 57-ft. long and have butt diameters ranging from 21-in. to 24-in. The bark was removed and the piles treated with two coats of "Cuprinol," followed by two coats of tar paint. The piles were driven on a batter of 1 in 25 into the berth at 13-ft. centres, the tops of the piles being afterwards fitted with cast-iron domed caps. Spring fenders consisting of double walings of 14-in. by 10-in. tallow-wood approximately 3-ft. 6-in. below deck level were housed and bolted to the piles. The back waling is securely fastened to buttresses, projecting 9-in. from the face of the wharf and placed between the pile centres. This arrangement permits of a flexure of 9-in. in the double walings between the points of support, and absorbs mooring impacts. The surface of the concrete piles down to low water, and the underside of the deck slab, were given two coats of tar paint.

Legal Notes

Limitation of Liability in Compensation Claim

In the Admiralty Division, judgment was recently delivered by Mr. Justice Langton on the question whether workmen's compensation claims and claims of burial expenses could be brought within a decree of limitation of liability. His Lordship found that they could not.

The Mersey Docks and Harbour Board had sought to limit their liability arising out of the stranding of the pilot boat "Charles Livingston" on Ainsdale Beach, Liverpool Bay, in a gale on November 26th, 1939. Twenty-three lives were lost, eight of them pilots, and Mrs. Marjorie Whitehead, widow of David Whitehead, deceased, was defendant with others to test the question whether these two classes of claims were not outside the operation of a limitation decree. Commander Edward Ernest Tully, father of John Spencer Tully, who lost his life, opposed the application to limit the liability, alleging negligence and breach of duty by the Board. On March 19th, Mr. Justice Langton delivered judgment on the case presented by Commander Tully, and found no fault or privity in the Board which disentitled them to the decree for which they asked. He reserved judgment, however, on the workmen's compensation point in order that he might look into the law and such authorities as bore on the question.

Judgment

Mr. Justice Langton said that when the Board sought to limit their liability in respect of the loss of their pilot boat "Charles Livingston," Mrs. Marjorie Whitehead contended that they could not limit their liability for a claim by her under the Workmen's Compensation Act, 1925, for the death of her husband, David Whitehead, or a claim for his funeral expenses.

This, the judge said, provided a problem not at all easy of solution. He found no direct authority on the point. Sect. 503, Sub-Section 1, of the Merchant Shipping Act, 1894, read:—

The owners of a ship British or foreign shall not, where all or any of the following occurrences take place without their actual fault or privity; where any loss of life . . . is caused to any person being carried in the ship . . . be liable to damages beyond the following amounts. . . .:

His Lordship noted that the words were "shall not . . . be liable to damages beyond the following amounts." The enlargement of the field of a right to limit made by the Merchant Shipping (Liability of Shipowners and Others) Act, 1900, did not extend the right pertinent to loss of life. Were those two items damages for which the shipowner was liable? He was certainly liable to pay them, but were they "damages" for limitation in the sense of the statute? The Act was unusually well-furnished with definitions. In addition to terms defined in other parts, Sect. 742 contained a list of over 30 terms which gathered into a startling companionship such incompatible notions as "bankruptcy" and "The Trinity House," and attempted to elucidate or amplify them by way of definition.

The term "damages," however, was not included in this far-reaching effort. In Prehn v. Bailey, the *Ettrick* [1881], 6 P.D. 127, a very strong Court laid down that the limitation of a shipowner's liability for damages was a limitation only of the consequences of his wrong-doing.

It did not otherwise alter the position. As a Master of the Rolls said: "It does not make his act right though previously wrongful. It does not give him any new rights, as far as I can see." Mr. Brightman claimed that this put the matter in the proper perspective. The shipowner was given relief in the matter of damages, and damages only, which were consequent on his wrong-doing. He was not given relief in respect of any other consequence or of any other liability.

In the *Annie* [1909] P. 176, Mr. Justice Bargrave Deane held that the plaintiff in a collision action, in the Admiralty Court, could recover as damages in that action a sum paid to the dependents of the master of his vessel under the Workmen's Compensation Act, 1906. In the *Moliere* [1925] P., Mr. Justice Roche following a decision of Lord Gorell in the *Circe* [1906] P., held that the plaintiff in a collision action *in rem*, where both vessels were found to blame, could not include as an item of damage against the defendant, compensation paid under a Swedish statute to the relatives of a seaman on the plaintiff's vessel. Mr. Justice Roche (Lord Roche) held further, that the Maritime Conventions Act, 1911 (Sect. 5), had not altered the law in this respect. The case of the *Annie* was authority for the proposition that in a common law action for damages a sum paid by way of compensation might be included under that head, but it did not carry the plaintiffs in this case the whole way.

Was it not possible that a plaintiff might be entitled to claim under the head of damages against a wrong-doing defendant, something which he himself had become liable to pay as the result of the tort complained of, but which could never have been claimed as damages against himself?

Harbour and canal authorities had frequently in their private Acts a right conferred on them to claim as against any shipowner whose vessel was sunk within their jurisdiction, the whole cost of removal of the wreck.

One might consult the *Millie*, 64 Ll. L. Rep., 318. Rights of this class were independent of any wrong-doing on the part of the shipowner concerned. Where an innocent vessel had been sunk by a wrongdoer the owner of the innocent vessel could no doubt recover against the wrongdoer as part of his damages the sum paid to such an authority for the removal of the wreck. But this did not make the original claim of the authority a claim for damages. It remained a claim for an indemnity quite independent of any right to damages.

It was pertinent to remember that although in the present case it happened that the shipowner-plaintiff had been liable to pay the compensation in question as a result of negligence by his servant, the claim was not based upon negligence. In this case, as in all other claims under the Workmen's Compensation Acts, the ground of liability was that the injury was by accident arising out of and in the course of the employment of the workman. The amount of the compensation was governed by statute and indeed in the present instance was fixed thereby, and in case of dispute was settled not by action but by arbitration under the Act. The distinction, therefore, between compensation as considered and thus arrived at and any known form of damages was real and wide.

Furthermore, if the plaintiffs' claim to limit in the present instance were admitted, the effect would be, as his Lordship understood, to cut down the amount fixed by a carefully framed scale in Sect. 8 of the Workmen's Compensation Act, 1925. One could not escape the reflection that if it had been intended by Parliament that the scale in question should be modified or truncated in the case of seamen in the manner suggested by the application of Sect. 503 of the Merchant Shipping Act, or any other limitation Act, some reference thereto would be found in a much later statute dealing with workmen's compensation.

The Judge added that he did not say the point was free from difficulty, but the consideration which he had outlined pointed, above all, to his mind, to the conclusion that the plaintiffs were not entitled to limit their liability in respect of these amounts.

"To this extent, therefore," the Judge concluded, "their claim will fail and the defendant, Mrs. Whitehead, will succeed. Commander Tully's defence having failed on the general question of limitation, the plaintiffs will be entitled to limit their liability in accordance with their prayer, save as regards Mrs. Whitehead.

The New Wharf at Durban.

Although still far from completion, the latest advices from South Africa show that the new T Wharf at Durban, Natal, has been partially brought into use. The finished length is to be 2,000-ft., and the two arms now project into the Bay 800 to 900-ft., leaving about the same length of wharfage to be constructed. Cranes have already been installed on the Western wall. The new wharf is designed to afford, on completion, accommodation for eight or ten vessels. A new pre-cooling store, to cost £270,000 and seven transit sheds are included in the scheme.

Concrete in Sea Water

Discussion on Mr. Homer Hadley's Paper

As a pendent to the Paper on the above subject* the following observations by Mr. W. F. Way, M.Am.Soc.C.E., are reproduced from the Proceedings of the American Society of Civil Engineers. It is Mr. Way's impression that Mr. Hadley's paper is timely. Too long it has been thought that all concrete, good or bad, deteriorates in sea-water structures, the deterioration being due to chemical reaction between the sea water and the various compounds in the hydrated cement of the concrete. Mr. Way agrees quite heartily with the conclusions in the paper. In fact, one cannot come to any other conclusion when observing in the same structure both sound and unsound concrete in close proximity. Concrete that was placed, probably, from the same bucket or buggy that is, concrete that has been under the same exposure is found partly sound and partly unsound. Surely the difference is not due to chemical action. True it is that concrete structures in sea water do not enjoy a flawless record; but it is also true that the real causes of unsound concrete have not been explained by the allegations of sea-water attack.

Mr. Way once had occasion to repair the substructure of a reinforced concrete pier whose supports were cylinders 4-ft. in diameter, belling out to bases of 13-ft. diameters. In the original cylinder construction, a timber shell form was made that was placed over a pile cluster previously driven, and when in place the marine ooze was pumped out and the base was sealed with a tremie plug. The next step was to dewater the form and to place the reinforcing steel. The base and shaft were completed with a concrete supposedly placed " in the dry." For various reasons a good job was not obtained, and years later after the teredos had eaten away the wooden forms (which had all been left in place) the concrete began to ravel away. The repair contract required all work to be done in the dry, which necessitated the use of a pneumatic caisson. This caisson enclosed the cylinders successively, one at a time, from high water to the mud line about 45-ft. Thereby an excellent opportunity was afforded to study this concrete after its fifteen years of service. The typical case showed lenses of mud through the base of tremie concrete, above which was a very lean concrete in the shaft capped off with a plug of solid laitance varying from 2 to 4-ft. thick, or sections of lean concrete separated by bands of laitance 6 to 12-in. thick. Many local areas of good solid concrete were encountered. It can be appreciated that this " failure of concrete " was due solely to poor workmanship, although the impression gained by many was that an inherent weakness of concrete when exposed to sea water had something to do with this failure.

The design of marine structures is a most important factor in determining the amount of maintenance that later will be required. Generally, designers have the option of using concrete piles or concrete cylinders in supporting pier decks. With concrete piles it is almost certain to be specified that all cracked piles shall be pulled and replaced with sound piles. Considerable controversy may arise over this point and therefore a brief description of a project in which 3,500 piles were driven may be apropos.

The piles on this job were 16-in. by 16-in. for lengths as great as 60-ft., and 18-in. by 18-in. for 60-ft. to 80-ft. lengths. All piles were driven with a double-acting hammer on a floating rig. These piles were carefully designed; the materials used were certainly of the highest quality; and the workmanship throughout, including curing, was in accordance with the very best practice (1933). When the piles were placed in the leads of the driver, no signs of cracks were visible. After they were driven each of the 3,500 piles was inspected by inspectors in diving suits, and it was found that practically every one had developed cracks during the driving. Only at the inshore and in shallow water where the piles were shorter (about 40-ft.), and the unsupported length during driving was 20-ft. or less, were no cracks observed. Since it would have been beyond reason to expect the contractor to pull these piles and drive others, a distinction was made on this project between a " cracked " pile and a " broken pile," under which it was considered that only such piles as were incapable of acting as elastic members would be rated " broken." Of the total number driven, about 60 piles were definitely " broken " and had to be replaced.

In reaching this decision about " cracked " piles an investigation was made of the piles in an adjacent existing structure, built fifteen years previously. The marine growth was removed and the faces of the piles were inspected carefully in an effort to locate cracks similar to those developing on the present job. As expected they were found; the concrete was then chipped back along the cracks, and in all cases the cracks were found to be opposite the reinforcing ties binding the vertical bars. They were all tight, and no signs of corrosion of either the bands or the main steel were observed.

Since it was definite that these cracks, which occurred opposite the bands, had developed during the driving it was decided that the new piles should be watched during the actual driving process. Because the water was warm, a shallow-water helmet was used, being safer and permitting freer movements around the pile. Furthermore, the large face plate affords excellent vision. After a pile was in the leads, the inspector, in a shallow-water suit, climbed on the pile, keeping under the barge as much as possible to protect himself from falling spalls. After a few blows the cracks would be observed forming, and as driving proceeded the cracks would start to " spit " out the crushed material ground up by each blow. In many of the piles there would be a crack opposite each reinforcing band. The conclusion was that as long as the bond on the main vertical steel was practically unimpaired there would be sufficient ground-up material remaining in each crack to re-cement itself and to protect the steel, and that the pile was as good as could be obtained. It is the writer's opinion that it is impossible to drive a pre-cast reinforced concrete pile, as now being made, without developing these small fine cracks, especially when the length is around 35 to 40-ft. from the mud line to the water surface. It is his further opinion that such fine cracks are not harmful if the concrete of the pile is of good quality, but that they are dangerous if the concrete is of poor quality. It all depends on " what kind " of concrete cracks.

Many instances of poor concrete have come to Mr. Way's attention, occurring both in fresh and salt water substructures, and also many examples of good concrete have likewise been observed. One that might be mentioned is a small sea wall built along the beach of Elliott Bay at Seattle, Wash. This wall is 5-in. thick at the top and 7-in. at the base, and 5-ft. high. The elevation of the top is at extreme high water. The wall is reinforced at the centre with $\frac{3}{8}$-in. round bars 15-in. on centres both ways. The concrete was made with the sand and gravel shovelled up from the beach, which at times contained a considerable quantity of sea water. The cement content was 6 sacks per cubic yard. The exposure is very severe and the wall has had to stand much pounding from both waves and drift. The wall is now (1941) thirteen years old and the only signs of distress are those due to erosion; no chemical deterioration can be observed.

*In the June, 1941, issue of "The Dock and Harbour Authority."

Goods Handling at British Ports

(Concluded from page 192).

thefts in the aggregate involve a heavy weekly loss in money value. The Sub-Committee, therefore, recommend that this matter should receive the attention of the Government Departments concerned, and further that the Ministry of War Transport should seriously consider the advisability of depriving the offender of his place on the register and therewith of his right to employment as a dock labourer.

Inland Sorting Depots

The Sub-Committee feel that, although the quicker turn-round of ships at some ports is being achieved, the inland transport and coal problems still remain, though temporarily the transport problem is easier owing to the extension of summer time. Insufficient progress, however, seems to have been made in connection with the provision of inland sorting depots which would enable the speedier dispersal of cargoes to be secured at the ports. The general view is held that such depots must be looked upon as a necessary and valuable measure in war-time only, and as unlikely to be of any material value afterwards. (During the last war the problem of securing rapid discharge from ports in France led to the successful introduction of modifications of peace-time methods based on the principle that ports should not be used as sorting or storage depots, but for transit purposes only). There would also appear to have been differences of opinion as to who should bear the cost of providing these inland depots. The Sub-Committee recommend that these urgently-needed facilities should be provided without further loss of time.

Summary of Recommendations as Regards Ports

The Sub-Committee recommend that:—

(1) Piecework rates for the handling of cargo should be extended wherever practicable.

(2) Small committees should be set up by the Minister of War Transport (at the more important ports) to enquire into and report upon the working of the new schemes introduced for the better control of dock labour as soon as they have been in operation for a period of three months, and that until this investigation has been made, similar schemes should not be introduced at other ports.

(3) Experienced canteen and welfare supervisors should be appointed and adequate and sustaining food supplies (especially boneless meat) should be provided at the port canteens.

(4) Consideration should be given to the imposition of heavier penalties upon those convicted of pilferage of food, etc., at the ports.

(5) Inland sorting depots should be provided without further loss of time.